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CONCEPTUAL DESIGN STUDY
SCIENCE AND APPLICATIONS SPACE PLATFORM (SASP)
FINAL BRIEFING

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

MCDONNELL DOUGLAS

CORPORATION

MCDONNELL DOUGLAS

CONCEPTUAL DESIGN STUDY
SCIENCE AND APPLICATIONS SPACE PLATFORM (SASP)
FINAL BRIEFING

OCTOBER 1980

MDC G9300

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-HUNTINGTON BEACH

5301 Bolsa Avenue, Huntington Beach, CA 92647

PREFACE

This document contains material prepared by McDonnell Douglas Astronautics Company for the Final (12th month) Briefing on the Conceptual Design Study of a Science and Applications Space Platform (SASP); as defined in the Statement of Work for Contract NAS8-33592 by Marshall Space Flight Center, where the contact is:

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PLATFORM CONCEPT OBJECTIVE

- PROVIDE HIGHLY-USEFUL, COST-EFFECTIVE FLIGHT ACCOMMODATIONS FOR LOW EARTH ORBIT PAYLOADS WHICH HAVE COMMON SUPPORT REQUIREMENTS

BASIC PLATFORM FAMILY

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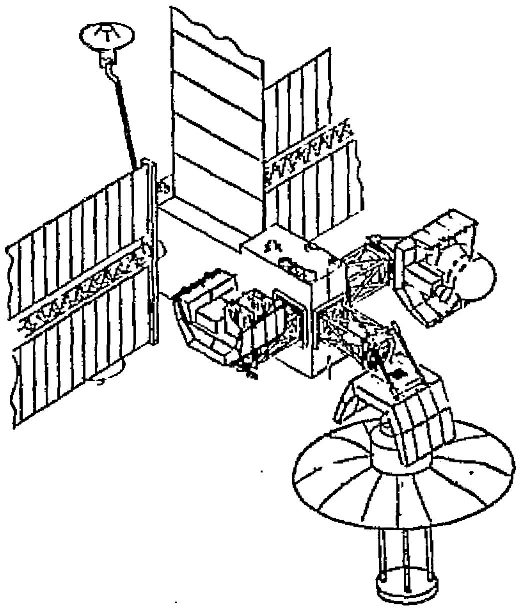
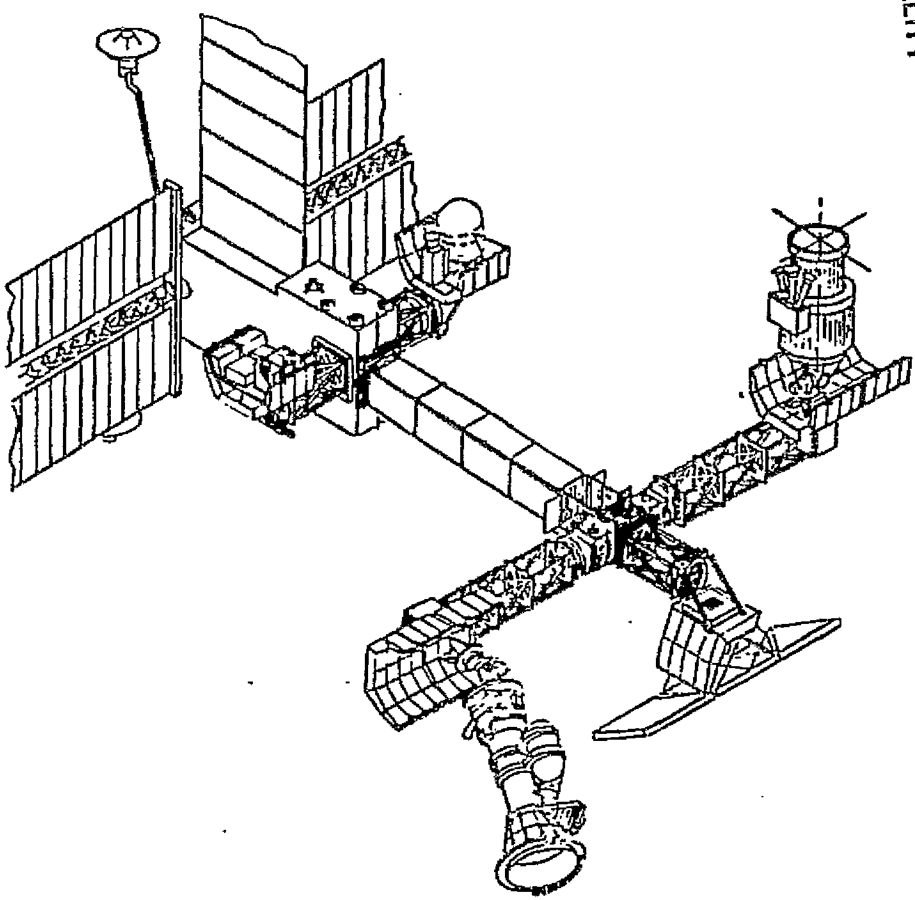
First Order



Second Order



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AGENDA

BENEFITS OF PLATFORM

- Major Improvements in Low Earth Orbit Payload Accommodations Provided Beyond Sortie Mode (With Minimal Payload Conversion)
  - Flight Duration
  - Environment
  - Resources
  - Physical Separation
  - Viewing Freedom
  - Cost Per Day of Flight
- Relief From Traffic Overload in NASA Support Systems
  - TDRSS (Single Access for Multiple Payloads)
  - Shuttle (Single Address for Multiple Payloads)
- "Total Package" of Resources Plus "Selective Supplementals" Available for Payloads, (Payload Does Not Have to Provide Own Solar Arrays, TDRSS Antenna, Radiators, or Recorders)
- Economical Alternative to Fleet of Smaller Spacecraft

PROGRESSION OF PAYLOAD ACCOMMODATIONS

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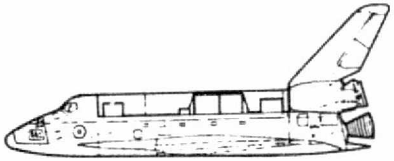
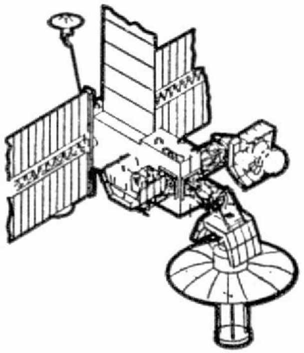
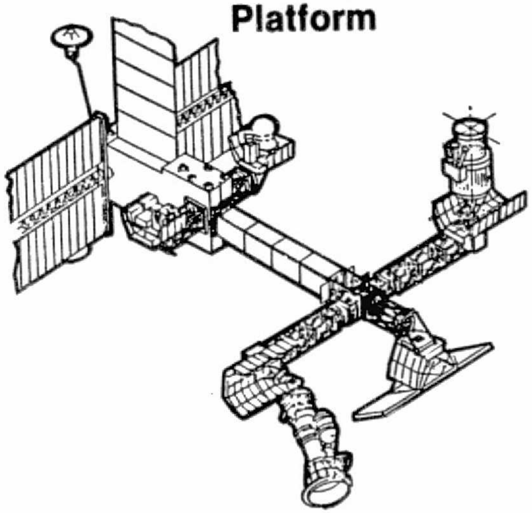
	1981	1986	1987
	Shuttle Cargo Bay Spacelab Sortie	First-Order Platform	Second-Order Platform
Flight Modes			
Payloads	Small/Medium Size: 7-14 Day Day Duration	Conversions for 3-6 Month Duration	Small/Medium/Large Sizes: Multi-Month-Year Duration
Pallet Separation	< 1 Meter	~4 Meters	~10-15 Meters
Viewing	• Unidirectional	• Quad-directional via 90° Step Rotation	• Tailored, Multidirectional via 360° Indexed Rotation
Contamination	• 10^{12} mol/cm^2 sec	• Est 10^8	• Est 10^8
Disturbances	• 36×10^{-5}g	• 1×10^{-5}g	• 1×10^{-5}g

PROFILE OF TYPICAL PLATFORM USERS

Payloads in Any of the Following Situations Will Benefit From Flights on Platform:

- Common Low Earth Orbit Interests
- Desire for Longer Flight After Sortie Flights With Minimal Conversion
- Benefits From Annual/Semiannual Access for Return/Recycle or On-Orbit Servicing
- Potential as Participant in Synergistic Group of Payloads of Significant Size
- Funding Prospects Which Preclude Use of Dedicated Spacecraft

OVERALL STUDY CONCLUSIONS

- Platform Configurations Can Effectively Support 80 to 85% of the NASA/OSS and OSTA Payloads Given for Consideration
- The Modularity, Shape, and Size of the Recommended Platform Concept Offers:
  - A Low-Investment, Early Option to Demonstrate System
  - Flexibility for Conservative Growth
  - Adaptability to Great Variety of Multi or Dedicated Payload Groups
  - Good Dispersion and Viewing Freedom for Payloads
- The Subsystem Approaches Recommended Are Based on Cost-Effective Distribution of Functions Among Payloads, Platform, the Power System and Ground Support
- The Great Number and Diversity of Payloads (50-60) Accommodated by the Concept Constitute a Sound Foundation
- Cruciform Platform Configuration With Rotary Joints on Each Leg Provide Good Viewing, Separation, and Loading Access

OVERALL STUDY CONCLUSIONS (CONTINUED)

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- Deployable Structures (Used in Extensions) Offer Stowage Compaction But Analysis and Testing is Required
- Payload Stability of 1.5 Arc Sec Can Probably Be Achieved With an Instrument Pointing System
- Transition of Sortie Payloads to Platform Will Be Minimum
- Shuttle RMS Support of Deployment/Loading Requires a Dual Hub Berthing Arm
- Reference Power System Fulfills Most Platform/Payload Requirements But Numerous Minor Changes Are Suggested

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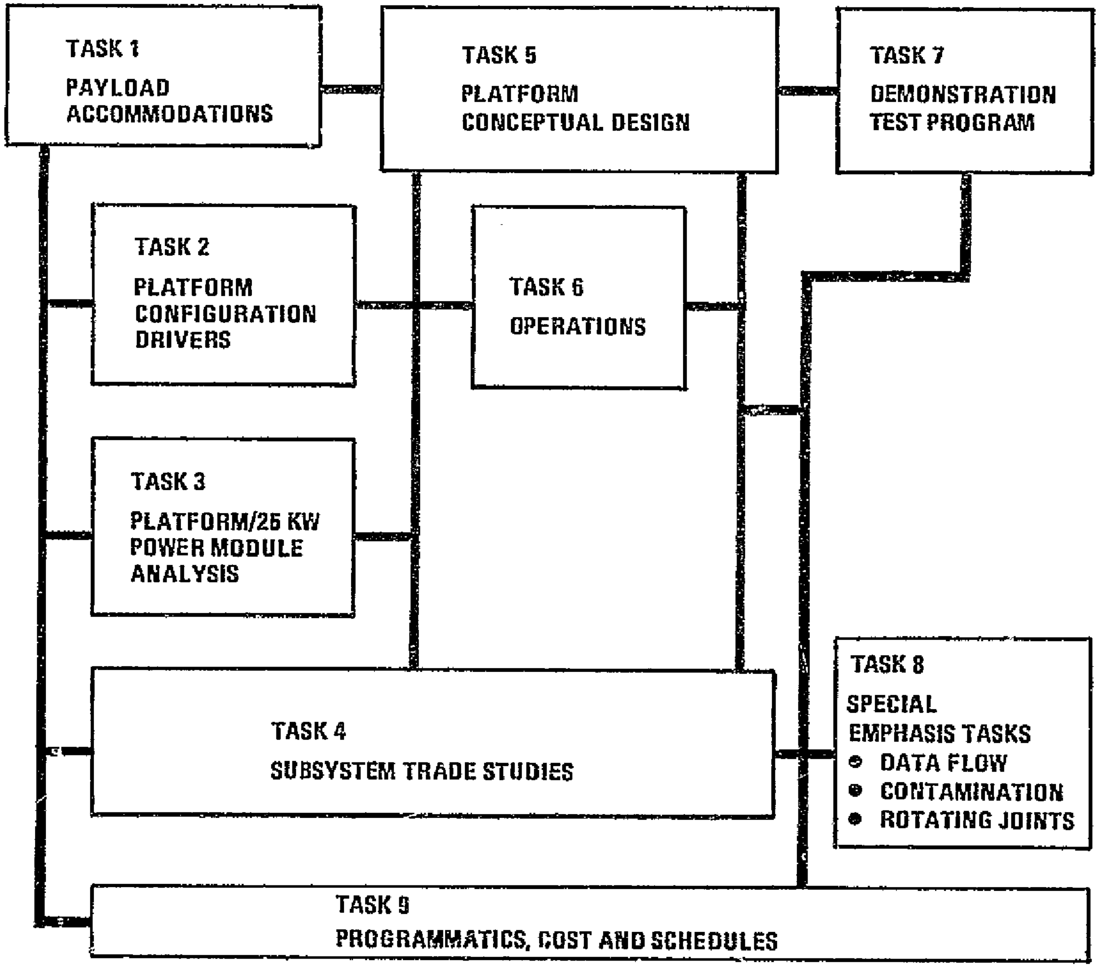
STUDY TASK FLOW

INPUTS

- NASA/MSFC REPORT ON PLATFORM
- USER REQUIREMENTS
- NASA/MSFC DEFINITION OF 25 KW POWER SYSTEM
- PRIOR CONTRACTOR STUDIES OF PLATFORM
- SPACE SHUTTLE USERS HANDBOOK
- TDRSS USERS GUIDE
- TIME-FRAME 1985-95
- LIFE: 10 YEARS
- PAYLOAD REQTS./ACCOMM. ASSESSMENT STUDY



PRODUCTS

- CONFIGURATION MATRIX OF PLATFORM CONCEPTS AND FEATURES
- SUBSYSTEM TRADES AND RECOMMENDATIONS
- SUMMARY DESCRIPTIONS OF SELECTED PLATFORM CONCEPT
- CONCEPT DESIGN DRAWINGS OF ONE OR MORE SELECTED CONCEPTS
- PRELIMINARY COST ESTIMATES, SCHEDULES AND WBS FOR SELECTED CONCEPTS
- PLAN FOR HIGH PRIORITY DEVELOPMENT NEEDS FOR NEAR-TERM PLATFORM AND DEMO PROGRAM

CONFIGURATIONS, OPERATIONS, AND PROGRAMMATICS

FRITZ RUNGE

PLATFORM CONFIGURATION EVOLUTION

Study Start

Guidelines

OSS and OA Payload Requirements and 1985-1990 Mission Model

- Orbit Inclination, Loads and Staytimes Indicate 4-5 Platforms With 4-6 Payloads Each
- Widely Separated Payload Berths (16-20m)
- Folding-Arm Plus Plug-In-Arm Cruciform

(Second Order)

Mid-Term

Added Task

Investigate "Minimum" Platform on Power System

- Early Basic Capability
- Focus on Converted Spacelab Payloads
- 3 Mini-Arms (3-8m Payload Separation)

(First Order)

Study End

Emerging Trend

Maximize Modularity to Increase Flexibility for Use and Rate of Investment

- New Concept Recommended for Follow-on Study
- All Plug-In Arm Cruciform

(Improved Second Order)

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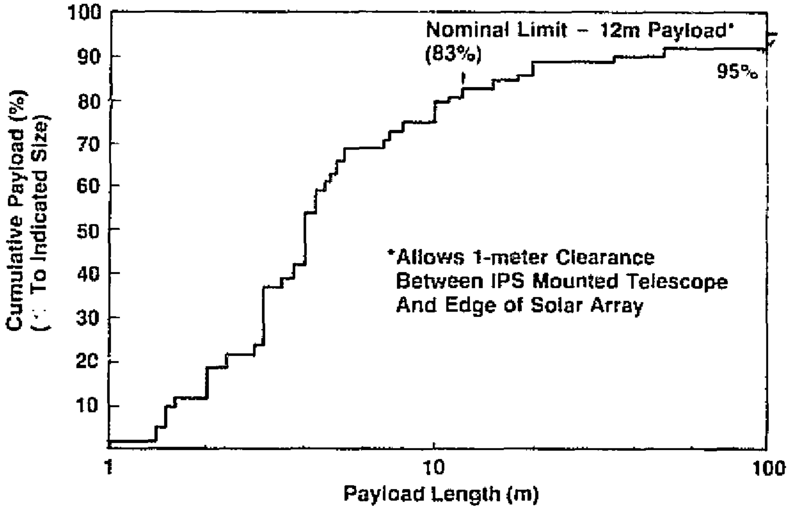
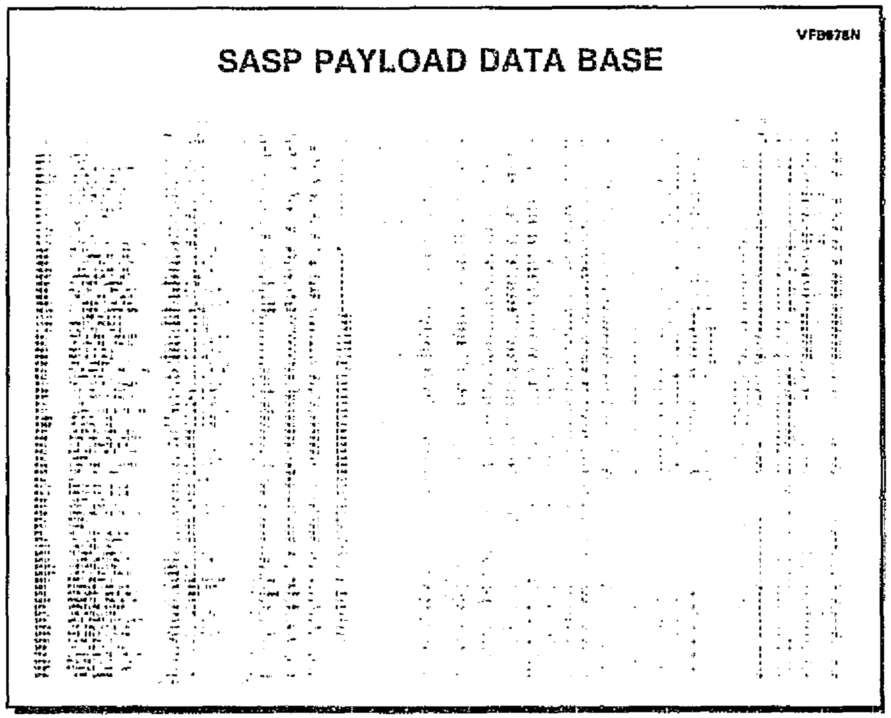
REQUIREMENT ENVELOPES

MAXIMUM PAYLOAD SIZE



- Based on OSS and OA Payload Descriptions and Model (1979)
- Developed Computerized Data Base
- Relegated Very Large Payloads to Adv Platform (LARC/MSFC Study)



PAYLOAD PARAMETERS EVALUATED

- Inclination Ranges
- Desired Inclinations
- Altitude Ranges
- Desired Altitudes
- Pointing Accuracy
- Pointing Stability
- Maximum Payload Dimensions
- Average Power
- Peak Power
- Data Rates
- Mass
- Thermal
- Servicing
- Viewing
- No. of Pallets
- Availability
- Orbit Stay

GROWTH IN VIEWING PAYLOADS AND ACCOMMODATIONS

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FIRST USE [OSS AND OA MODEL]	PAYLOAD SIZE Volume: m^3 (No. of Pallets)	Mix Through 1990
1981	<10 (<1)	20%
1981	10-30 (1)	45%
1984	30-90 (2-3)	20%
1986	90-150 (4-5)	15%
1987		
1990	Very Large Payloads (25-100-meter Diameter)	

FLIGHT ACCOMMODATION

SHUTTLE SORTIE
- Payloads in Cargo Bay

FIRST ORDER PLATFORM
- 3-meter Arms/1 Payload Each

SECOND ORDER PLATFORM
- 10-meter Arms/1 Payload Each

SECOND ORDER PLATFORM PLUS SIDEARM EXTENSIONS
- 24-meter Arms/2 Payloads Each

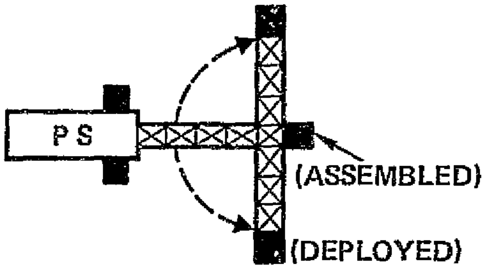
ADVANCED PLATFORM
- 48-meter Arms/2 Payloads Each
  Moveable Construction Aids

CURRENT PLATFORM FAMILY

1ST ORDER PLATFORM

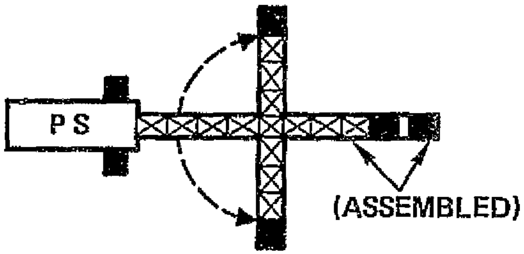
- 3 MINI-ARM PAYLOAD BERTHS WITH ±90° ROTATION STEPS

BASIC 2ND ORDER PLATFORM



- 2 MINI-ARM PAYLOAD BERTHS
- 3 MAXI-ARM PAYLOAD BERTHS
  - – GREATER POWER USE POTENTIAL
  - – GREATER PAYLOAD SEPARATIONS
  - – IMPROVED PAYLOAD VIEWING
    - 2 INDEPENDENT 360° ROTATING MAXI-ARMS
    - DECREASED INTERFERENCE
    - DECREASED OBSCURATION

2ND ORDEP PLATFORM WITH TRAIL ARM



- 2 MINI-ARM PAYLOAD BERTHS
- 4 MAXI-ARM PAYLOAD BERTHS
  - – MORE POWER USE POTENTIAL
  - – MORE IMPROVED PAYLOAD VIEWING
    - 3 INDEPENDENT 360° ROTATING MAXI-ARMS

■ PAYLOADS

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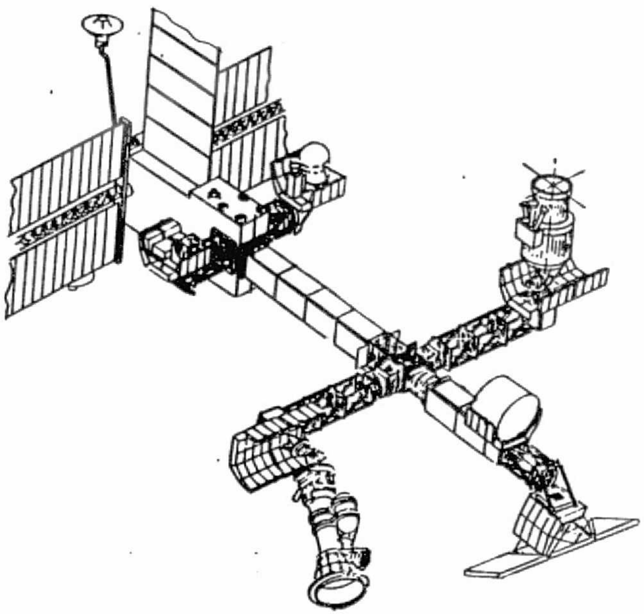
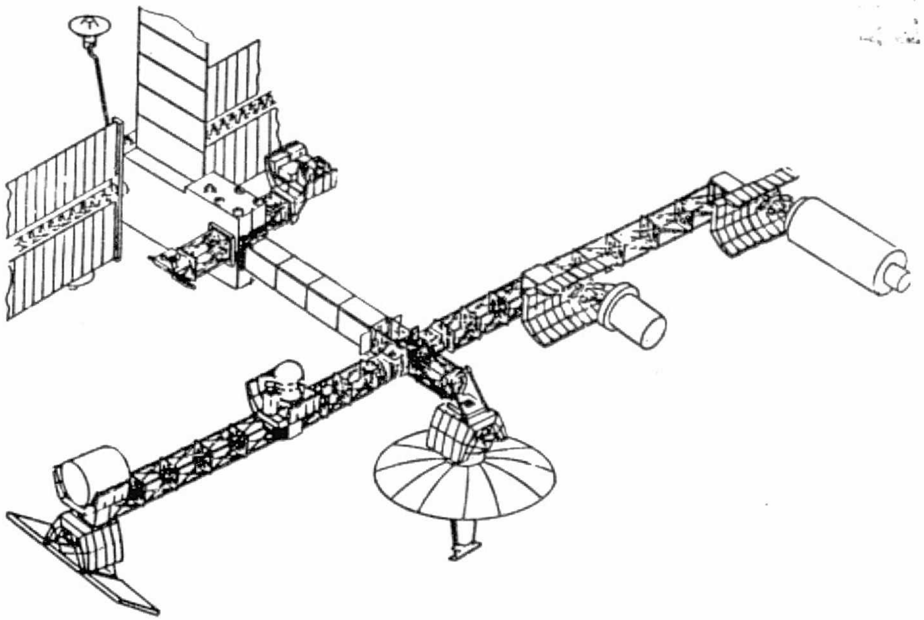
EXTENDED PLATFORM FAMILY

Second Order Plus Trail Arm Extension



Second Order Plus Side Arm Extensions



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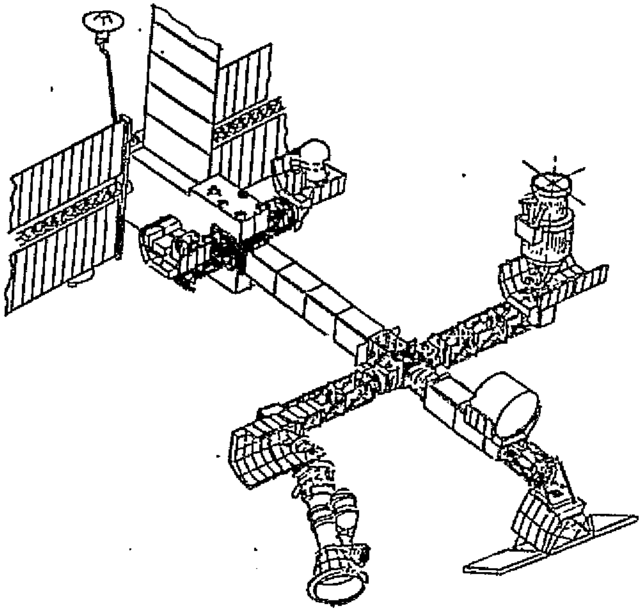
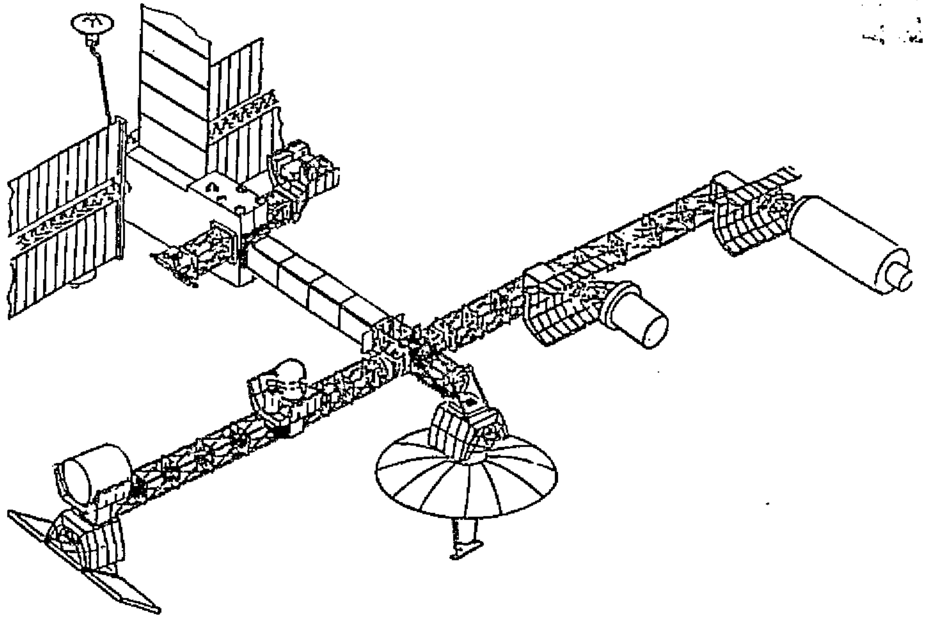
EXTENDED PLATFORM FAMILY

Second Order Plus
Trail Arm Extension



Second Order Plus
Side Arm Extensions



PLATFORM PARTS CATALOG

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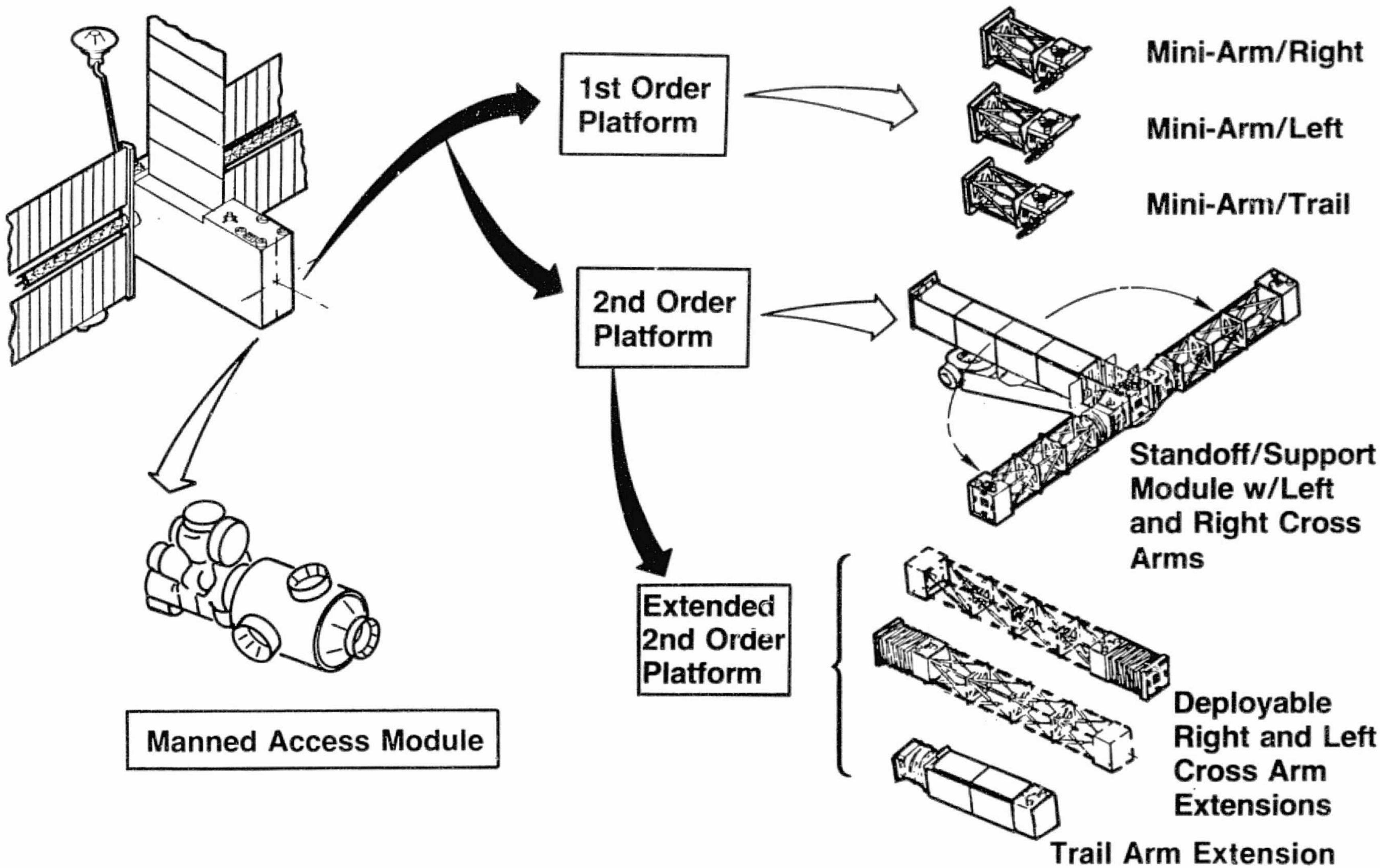

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PLATFORM PARTS CATALOG

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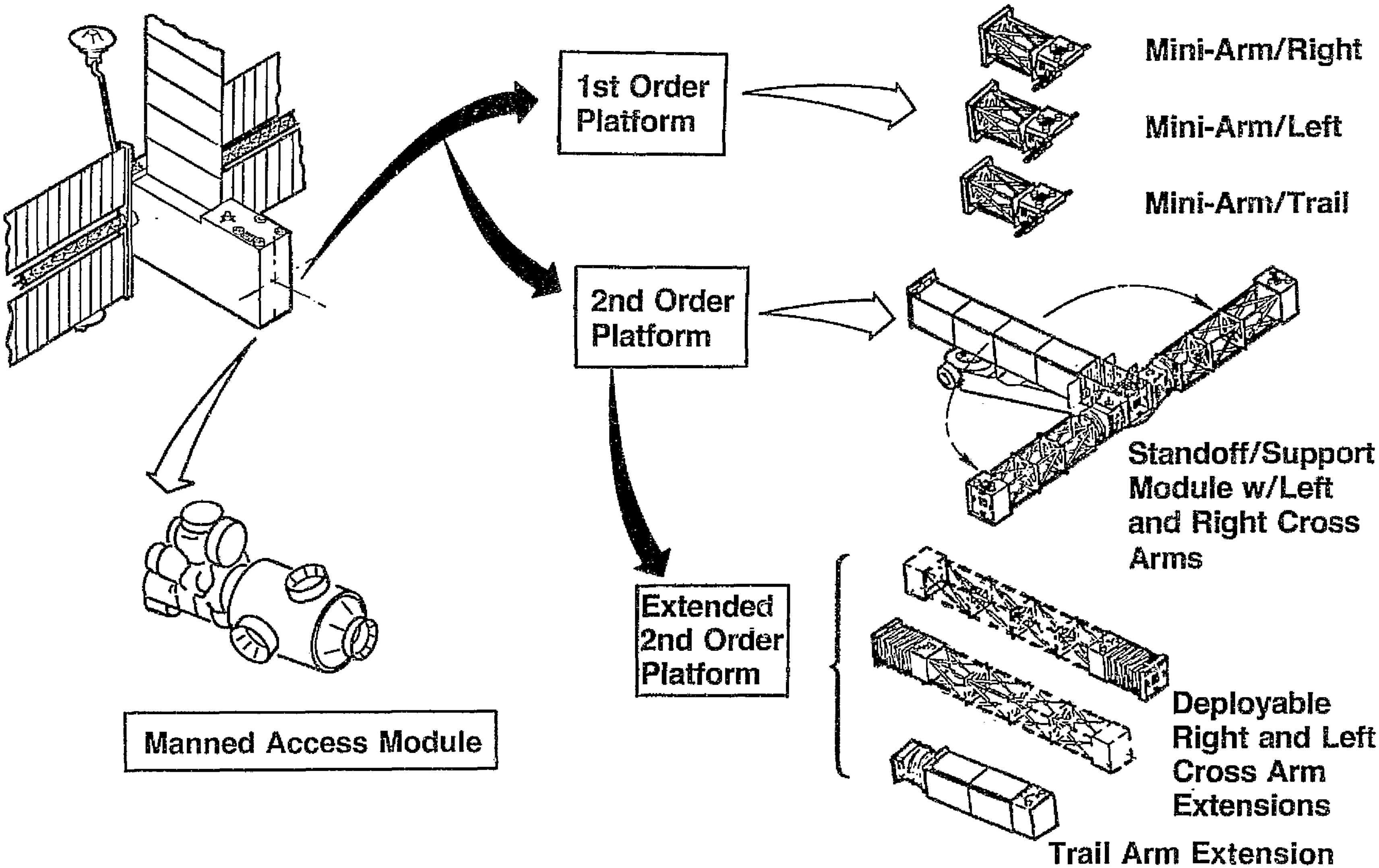

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CONFIGURATION TRADES

FIRST ORDER	CONCLUSIONS
2 Versus 3 Versus 4 Payload Berthing Ports	3 Active Payload Berthing Ports
Fixed Versus Movable Berthing Ports	4 Position Clocked Berthing Ports
Bottom Versus End Mounted Pallets	Bottom Mounted Pallets
Standoff Mini-Arms Versus Direct-to-Power System Pallet Mounting	Standoff Mini-Arms
Fixed Versus Schedulable Vehicle Orientation	Orientation Variable
SECOND ORDER	
Basic Shape and Compaction (Many Concepts Evaluated)	Folding Cross-Arms With Fixed Standoff Structure (T-Bar)
2 Versus 3 Arms	Payload/Program Dependent
Degree of Arm Rotational Capability	±180° Full-Length Arms 360°Mini-Trail Arm
Payload Berth Separation	13.2 m
PS Standoff Separation	13.4 m
Fixed Versus Schedulable Vehicle Orientation	Variable Orientation
Number of Primary Berthing Ports	5 to 9 Program Dependent

CONFIGURATION TRADES

FIRST ORDER	CONCLUSIONS
2 Versus 3 Versus 4 Payload Berthing Ports	3 Active Payload Berthing Ports
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PS Standoff Separation	13.4 m
Fixed Versus Schedulable Vehicle Orientation	Variable Orientation
Number of Primary Berthing Ports	5 to 9 Program Dependent

FIRST ORDER PLATFORM CONFIGURATION

Various pallet mounting configurations were reviewed (see upper chart) and the bottom-mounted pallet concept was selected. The lower chart illustrates various pallet mountings which require EVA for viewing direction change to the fully remotely automatically operated arm.

The 1st order SASP has three identical structural configuration arms except for the rotational features. The +X and -Y rotates clockwise and the +Y arm rotates counterclockwise looking outboard from the Power System.

The Concept 4 automatic four position will allow the maximum viewing capability for this low-cost First Order SASP.

FIRST-ORDER PLATFORM

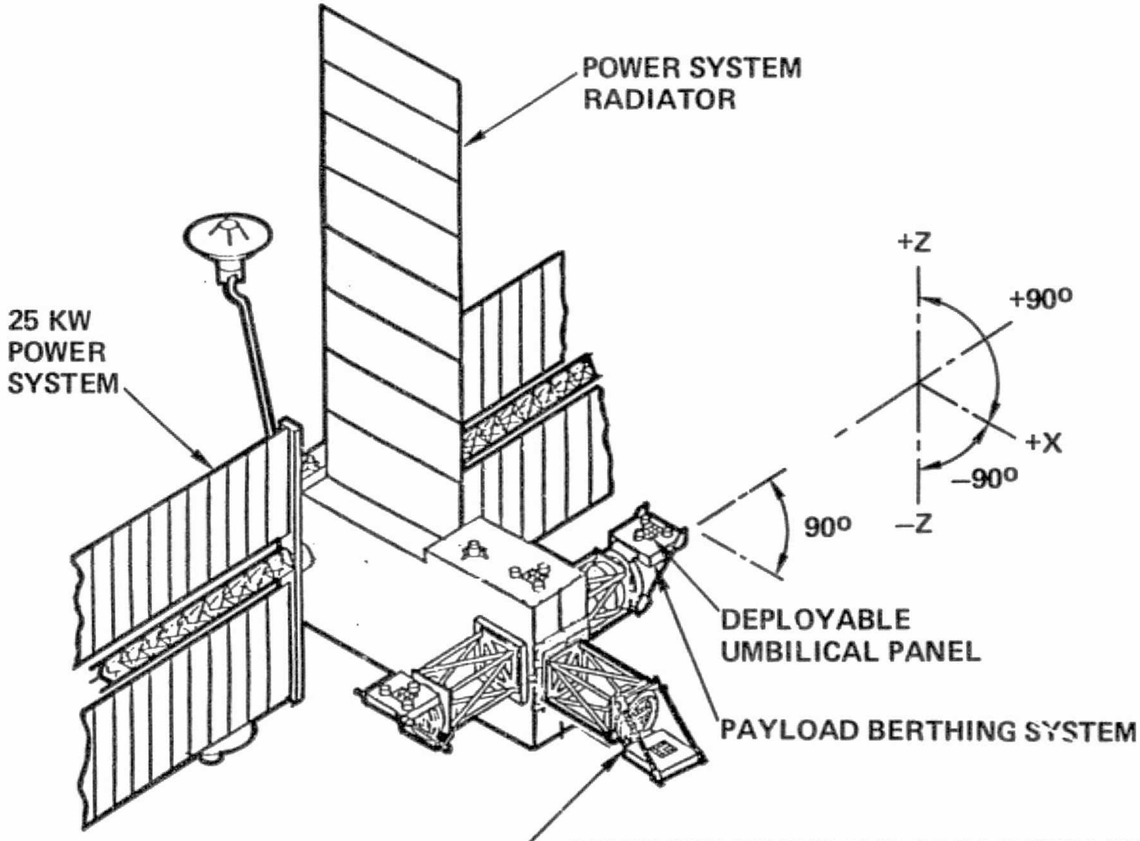
SYSTEM CAPABILITY
- 4 BERTHING PORTS (1 PARK)
- ENVIRONMENTS $\leqslant 10^{-5}$g's
- SELECTABLE 4 DIRECTION VIEWING PER PORT
- 3 PAYLOAD ELEMENTS CAN VIEW SAME DIRECTION (DEDICATED PLATFORM)
- NO VIEW OBSCURATION IN AT LEAST ONE DIRECTION
- WEIGHT (EXCLUDING PS) =~ 2,623 LB

SUBSYSTEM CAPABILITY

POWER
- 25 KW TO EACH BERTHING PORT
- 120 VDC AND 30 VDC

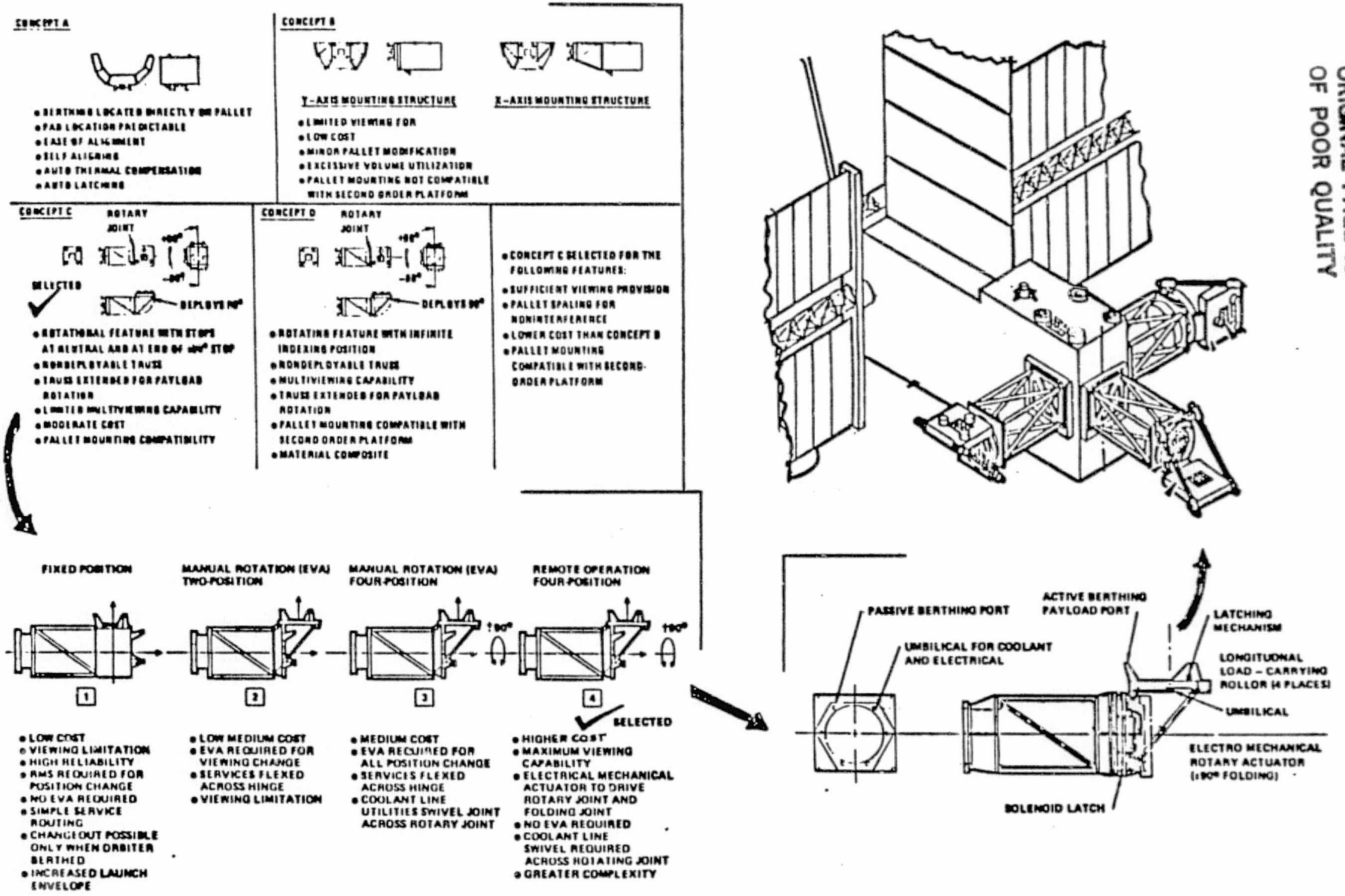
THERMAL CONTROL
- 10 – 16 KW HEAT REJECTION AT EACH BERTHING PORT

STABILITY AND CONTROL
- WITHOUT POINTING SYSTEM
  - ACCURACY = 0.3° – 2°
  - STABILITY ±1 ARCMIN
- CROSS POINTING VIA PLATFORM ORIENTATION



COMMUNICATIONS AND DATA HANDLING
- TDRSS CAPABILITIES WITHIN PS LIMITATIONS
- SPACELAB EQUIVALENT MULTIPLEXING AND DATA STORAGE
- PS COMPUTERS PROVIDE EXECUTIVE CONTROL

FIRST-ORDER PLATFORM CONFIGURATION



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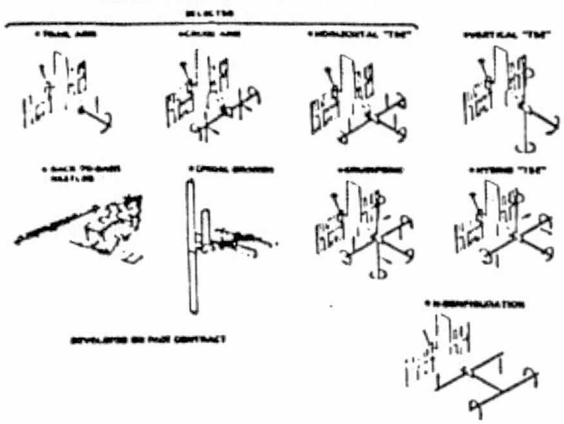
CONFIGURATION EVALUATED



CONFIGURATION SHAPE AND SIZE

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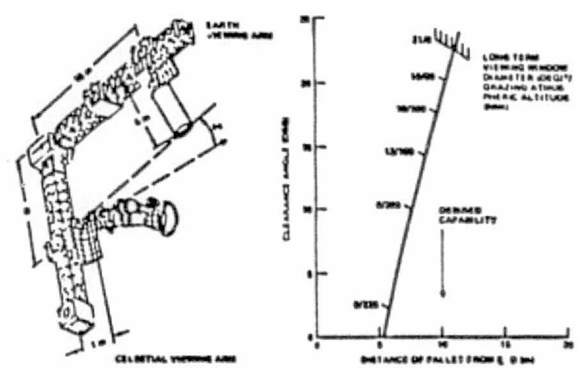
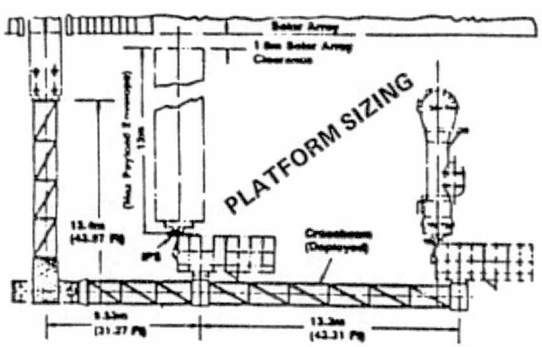
IMPACT OF PALLET LOCATION



- Cruciform Is Best for Multidirectional Viewing
- 13 to 20m Physical Separation Accommodates Variety and Sensitivities of Viewing/Sensing Payload Groups
- Size and Scanning Cone of Payloads Drive Platform Configuration



SIZE SENSITIVITY

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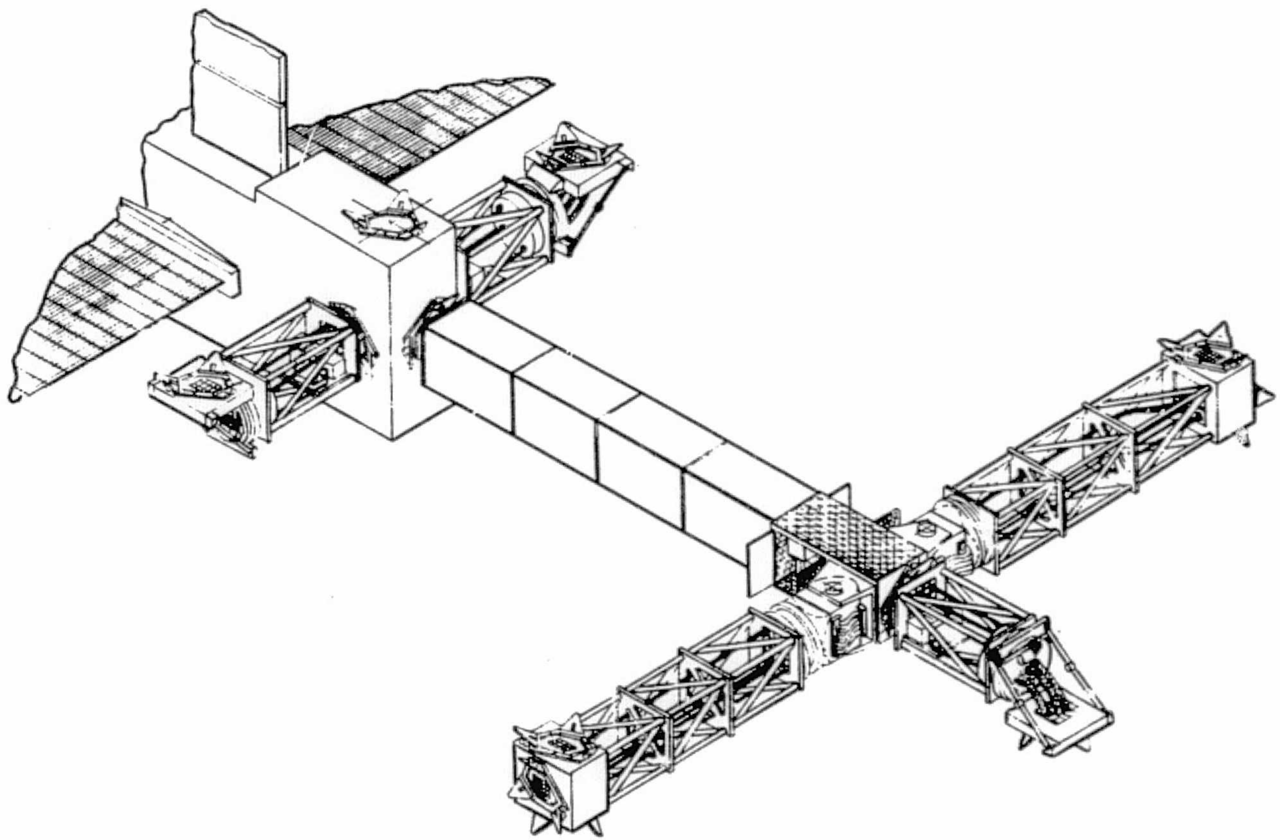
BASIC 2ND ORDER PLATFORM

The basic 2nd Order Platform is an extension of the 1st Order Platform. The initial growth is accomplished by adding a 13.4 m long support module with two 9.75 m long cross arms. The two cross arms incorporate an active interface mechanism to accept a cross arm extension as required. The support module incorporates a 1.42 m x 1.52 m x 3.0 m long subsystem section and a 10.4 lg structural standoff. The standoff structure incorporates the additional thermal control radiators necessary to satisfy payload requirements and assures adequate clearance between the PS solar array and platform-mounted payloads. The support module also incorporates the SASP/Orbiter interface berthing mechanism and an active interface system on the (+X) axis to accept a 1st Order Platform structural unit on a trail arm. The basic 2nd Order SASP consists of five (5) basic elements; One (1) Power System, three (3) 1st order payload structural adapters, and one (1) 2nd order support module assembly. The configuration shown can accommodate up to seven (7) payloads with one (1) parking port.

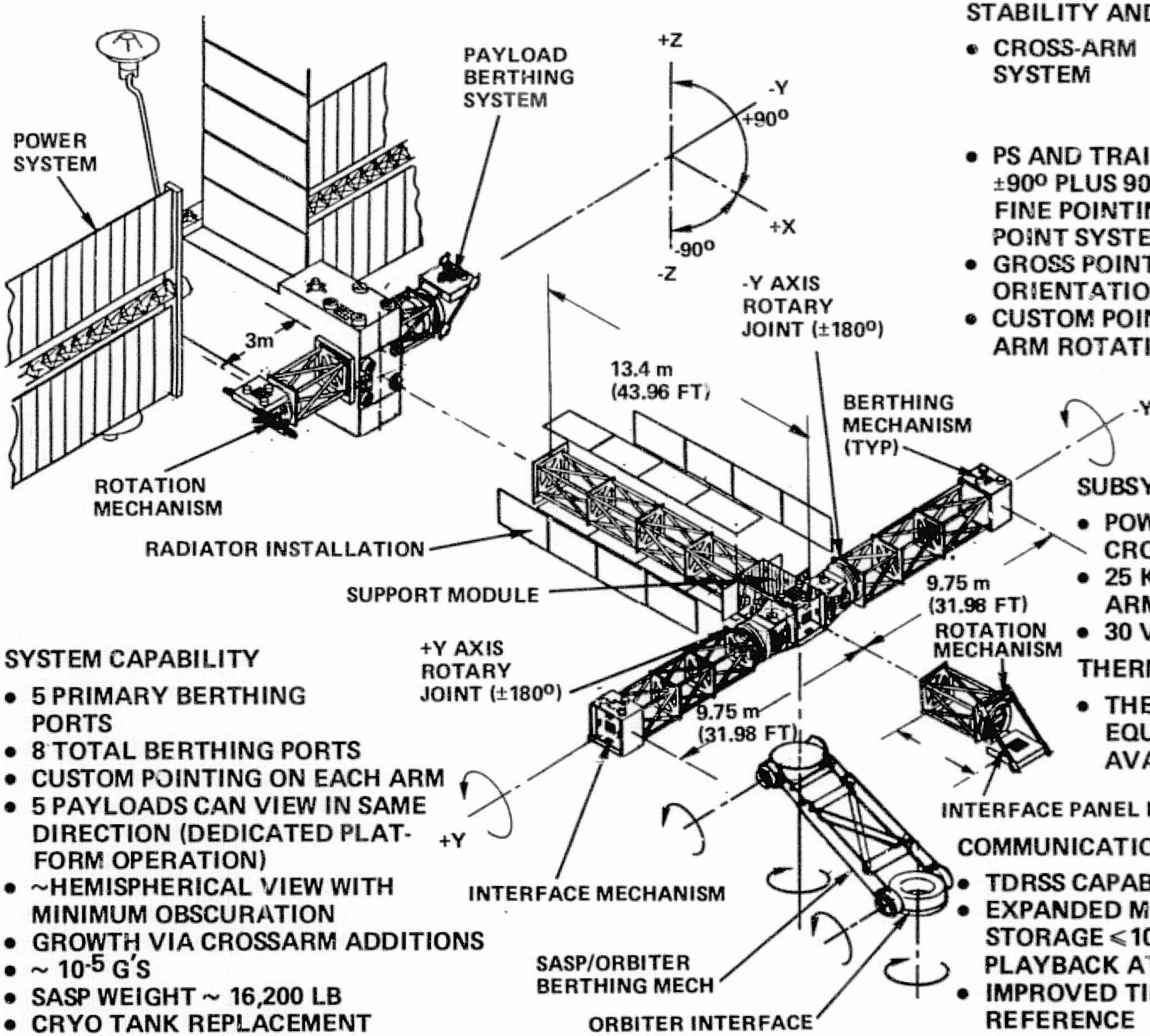
BASIC 2ND ORDER PLATFORM



SECOND ORDER PLATFORM

Platform capability growth is illustrated here with the addition of the "T" structure that provides standoff clearance for the payload crossarms, a platform radiator, and five new docking locations. Original first order platform arms can be retained to permit loading of payloads at the Power System. Their ports meet the low g level requirements for Materials Processing and Life Sciences payloads.

SECOND ORDER PLATFORM



STABILITY AND CONTROL

- CROSS-ARM SYSTEM W/O POINTING 0.3–2 DEG ACCUR ~1 ARCMIN STABILITY
- PS AND TRAIL ARMS ±90° PLUS 90° HINGE FINE POINTING REQUIRES POINT SYSTEM
- GROSS POINTING VIA SASP ORIENTATION
- CUSTOM POINTING VIA ARM ROTATION

SUBSYSTEM CAPABILITY

- POWER 6 KW PER PORT ON CROSSARM (AUG)
- 25 KW ON PS PORTS AND TRAIL ARM INTERFACE
- 30 VDC AND 120 VDC

THERMAL CONTROL

- THERMAL REJECTION EQUAL TO POWER AVAILABLE

COMMUNICATIONS AND DATA HANDLING

- TDRSS CAPABILITIES
- EXPANDED MULTIPLEXER AND DATA STORAGE $\leqslant 10^{11}$ BITS PLAYBACK AT $\geqslant$200 MBPS
- IMPROVED TIMING AND POSITION REFERENCE

SYSTEM CAPABILITY

- 5 PRIMARY BERTHING PORTS
- 8 TOTAL BERTHING PORTS
- CUSTOM POINTING ON EACH ARM
- 5 PAYLOADS CAN VIEW IN SAME DIRECTION (DEDICATED PLATFORM OPERATION)
- ~HEMISPHERICAL VIEW WITH MINIMUM OBSCURATION
- GROWTH VIA CROSSARM ADDITIONS
- ~ 10^{-5} G'S
- SASP WEIGHT ~ 16,200 LB
- CRYO TANK REPLACEMENT

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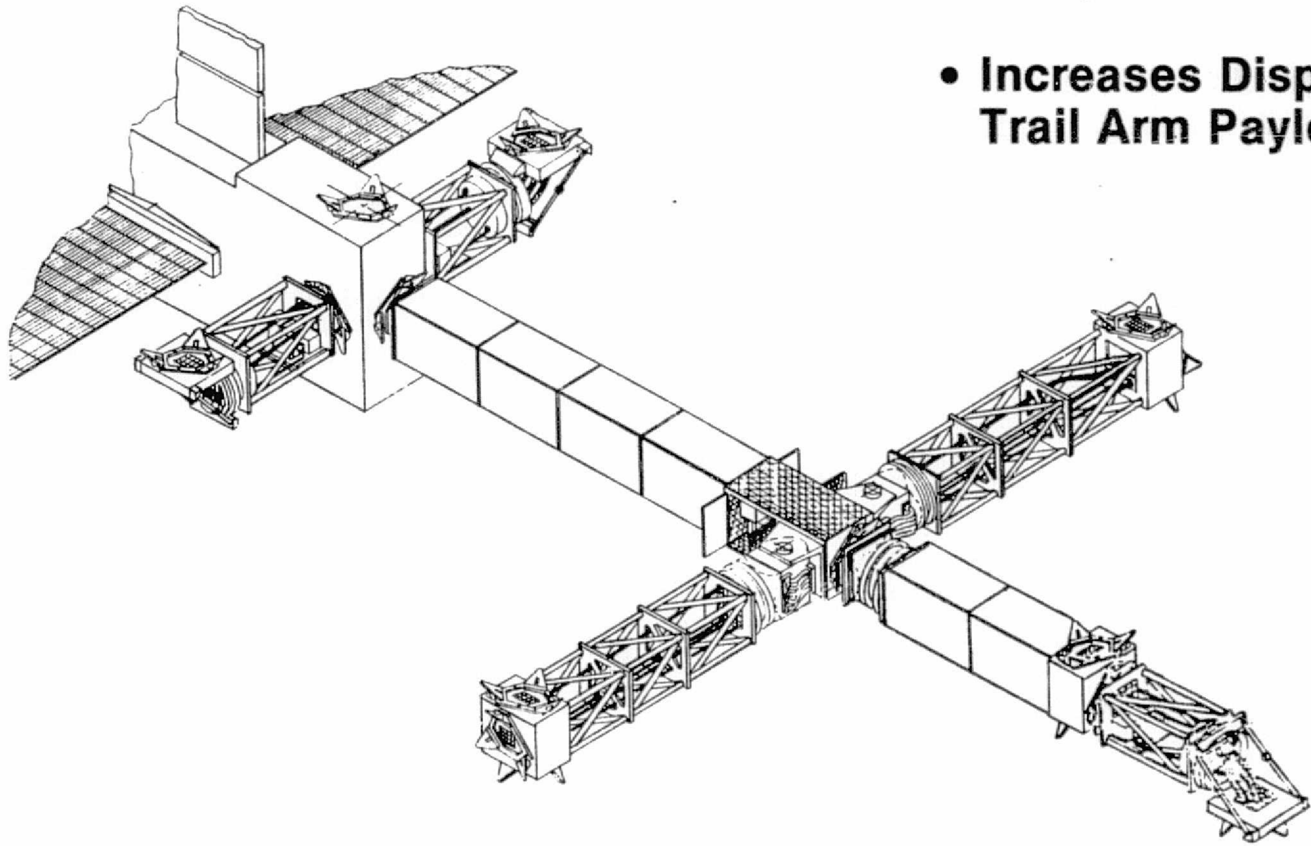
BASIC PLATFORM WITH TRAIL ARM

- Adds Trail Berth(s) and Independent Radiator
- Increases Dispersion of Trail Arm Payloads



STRUCTURAL INTERFACE MECHANISMS

The basic 2nd Order Platform incorporates two cross arm designed with a folding joint to facilitate compaction for launch and a $\pm 180°$ rotating mechanism to accommodate payload viewing and servicing. Space qualified rotary actuators are utilized to drive the folding and rotating joints with rollers incorporated to carry the longitudinal loads across the rotating joint.

The berthing mechanism selected is the concept being developed by MDAC for JSC. The system is designed to capture and berth any payload within $\pm 15°$ pitch and yaw and $\pm 6''$ misalignment.

STRUCTURAL INTERFACE MECHANISMS

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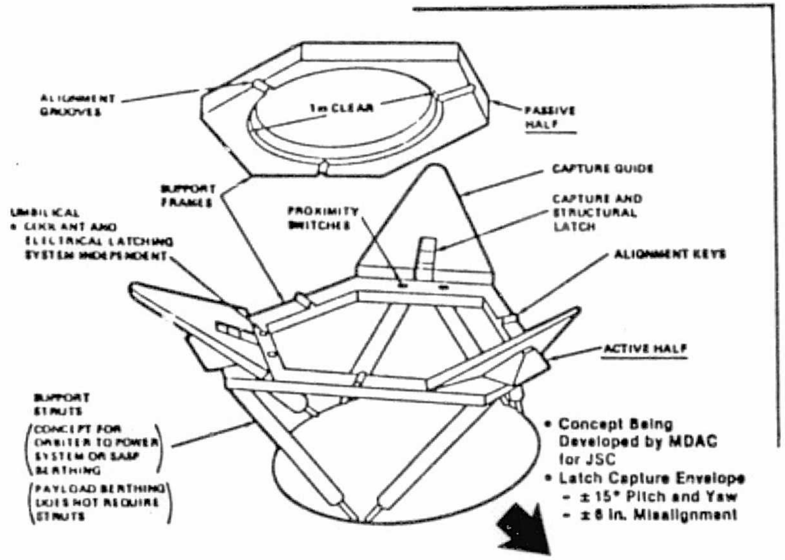
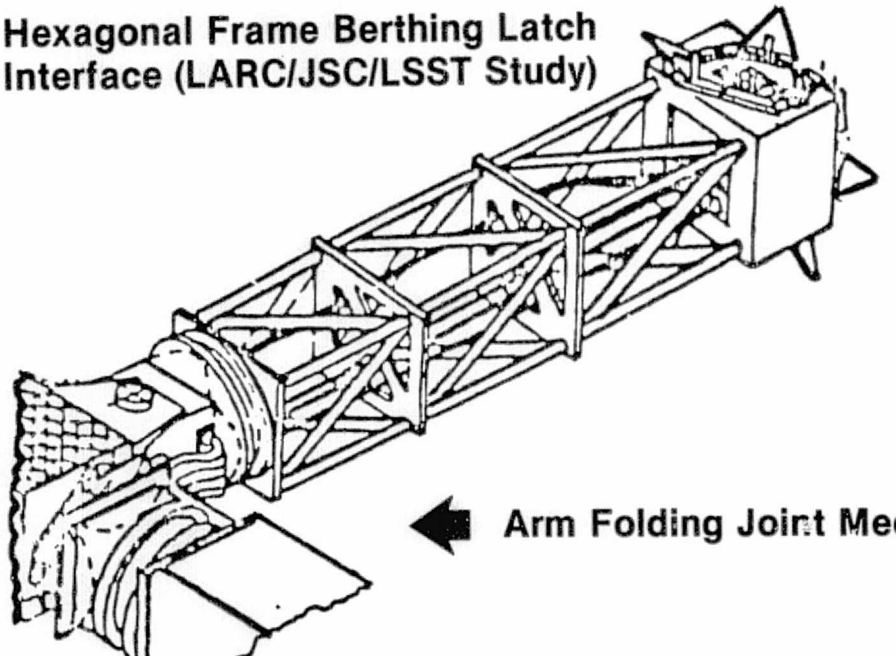
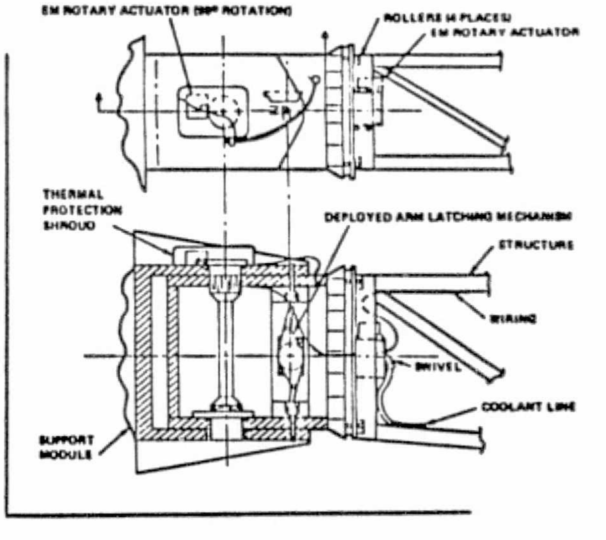


Hexagonal Frame Berthing Latch Interface (LARC/JSC/LSST Study)



Arm Folding Joint Mechanism

- Transfer Functions
  - Loads
  - Utilities
  - Volume (for Compaction)



TRAIL ARM 360° ROTARY JOINT

The rotating joint provides such features as 360° rotation, passive umbilical and berthing port infinite indexing position, quick change out of the drive motor, and complete rotary joint in case of electrical transfer failure. The passive berthing port will have provisions for coolant Q/D but is not required for this configuration. The unit only transmits power and data across joints by means of slip rings. It is capable of transmitting 25 kW of power and 100 Mbps of data.

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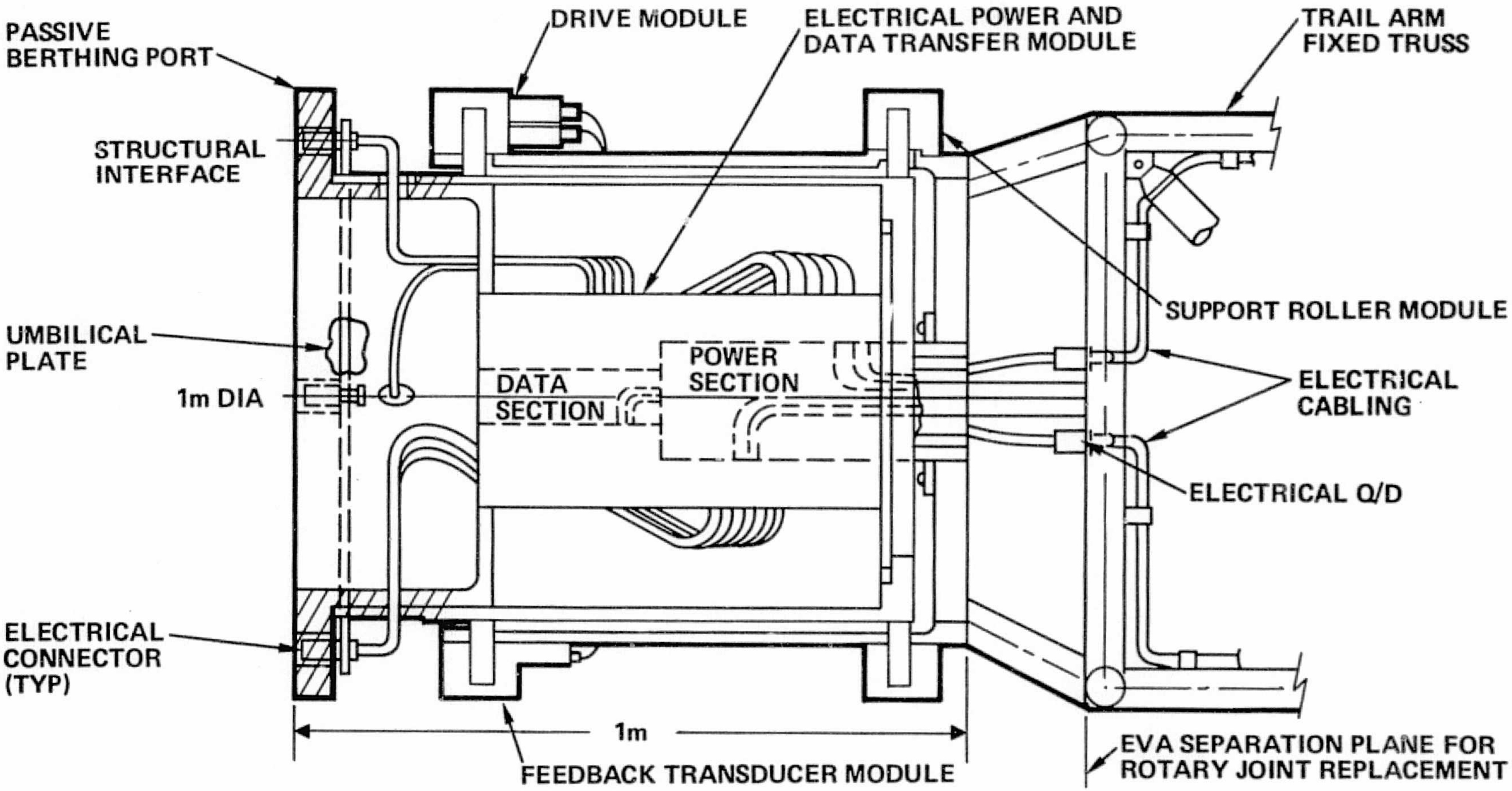
TRAIL ARM 360-DEG ROTATIONAL JOINT



- No Fluid Transfer Across Rotating Joint
- 360-deg Rotational Feature
- Complete Module EVA Replaceable
- 25-kW Power Transfer Capability
- 100-mbps Data Transfer Capability

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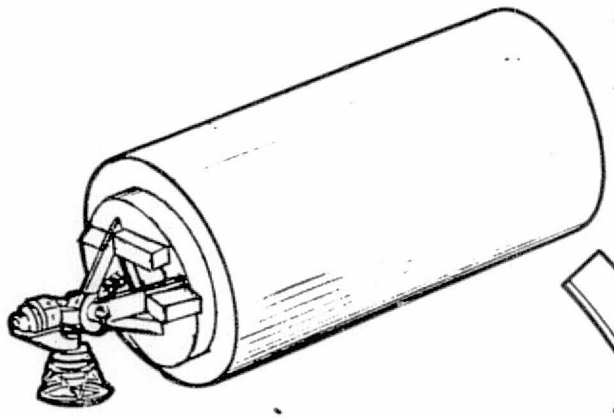
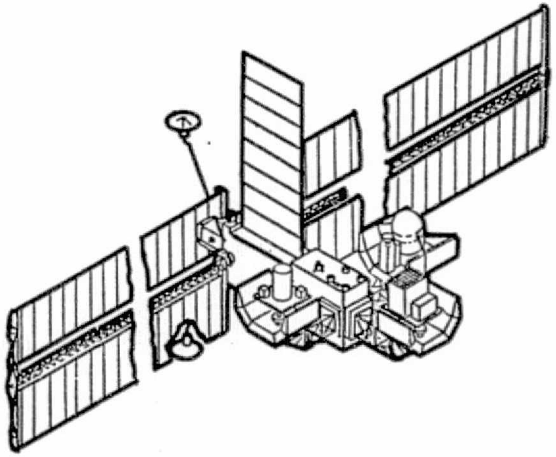
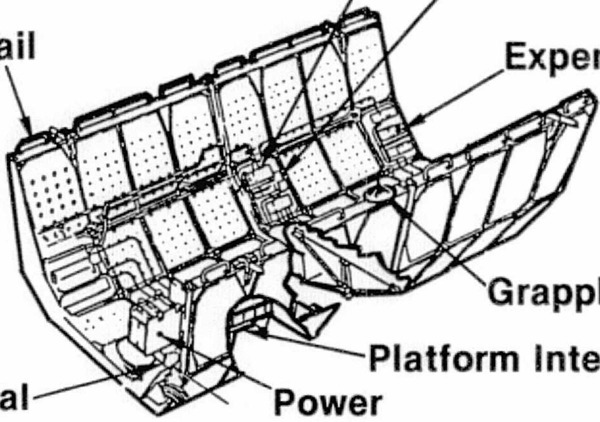
MINIMAL TRANSITION FOR PAYLOAD/PALLET INTERFACE

VFD186N



Spacelab Payload Converted from 7-Day to 3-Month Flight Capability





Platform-Type Pallet

- Payload/Pallet Interface
  - Mechanical
  - Power
  - Data/Comm
  - Thermal

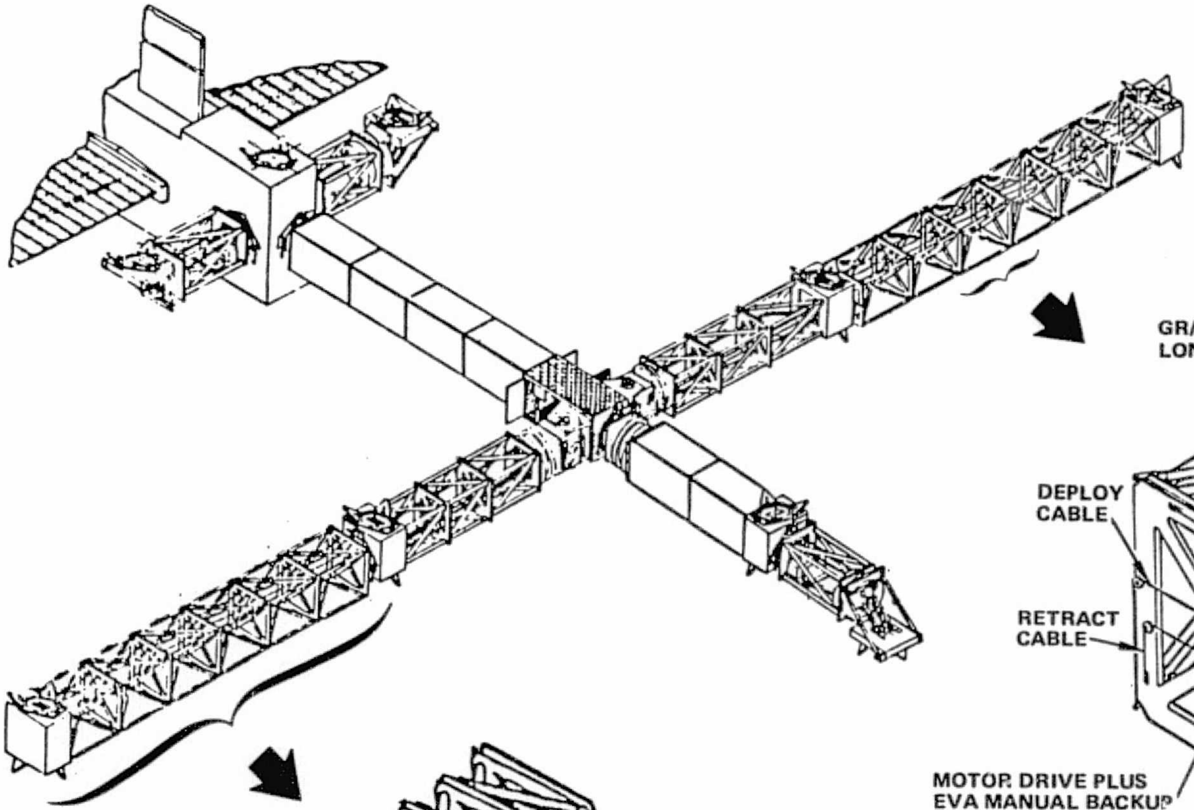
  } Same as Sortie
- Platform/Pallet Adaptions
  - Add RMS Grapple Fitting
  - Caution and Warning to Orbiter During Ascent
  - Minor Utilities Routed to Orbiter Thru SASP Umbilical
  - Internal Pallet Wiring to SASP Umbilical

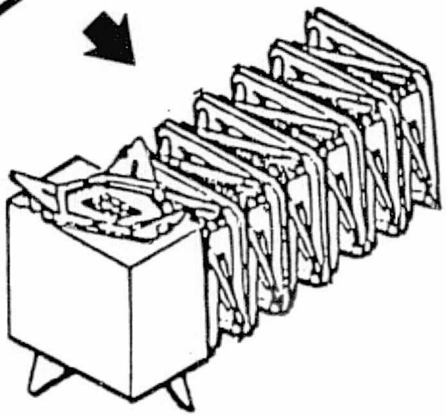
EXTENSION TRUSS

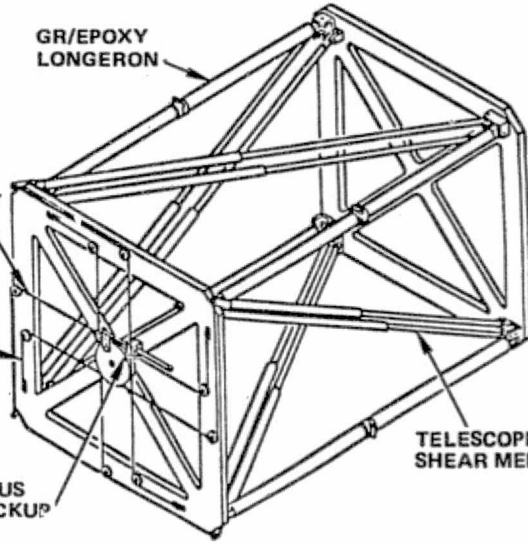
The basic 2nd Order Platform capabilities are extended by incorporating expandable structural cross arms. The expandable arms incorporate telescoping shear members and folding longerons deployed with a power-driven cable system with a manual backup. The arm compaction ratio is approximately 10 to 1. Wiring and plumbing are routed through the expanding structure using a convoluted tubing concept thus eliminating quick disconnects and swivel fittings. The arm incorporates a passive interface mechanism that interfaces with the basic cross arm and is assembled with the RMS. Two payload ports are provided, thereby doubling the experiment capability of the 2nd Order Platform.

VFG198N

EXTENSION TRUSS







- **Sized for ±60° Cone Instrument Pointing Freedom Among Adjacent Payloads**

- **Compacted for Delivery With Basic Platform (or Later)**

PLATFORM WEIGHT SUMMARY

Subsystem	First Order	Second Order		
		Basic Cross Arms and Standoff	Trailing Arm	Deployable Arms (2)
Structure/Mechanical	2206	4327	1091	3088
Berthing Provisions	1125	1566	816	1320
Subsystem Module	—	469	—	—
Truss and Supports	681	1332	275	1768
Adapters	400	960	—	—
Thermal Control	165	1287	631	165
Radiators	—	600	300	—
Cold Plate	—	125	65	—
Control and Lines	165	267	118	165
Fluid	—	295	148	—
Avionics	60	390	71	142
Attitude Control	—	470	—	—
Power Distribution and Control	483	1375	248	776
Distributors	318	165	54	—
Controls	—	46	—	—
Cables	165	1164	194	776
Subtotal (lb)	2914	7849	2041	4147
Contingency (25%)	730	1962	510	1043
Total Projected Weight (lb)	3643	9811	2551	5214

PLATFORM COST ESTIMATES

The cost for the platform portion of the SASP program (shown on this chart) assumes the First Order unit is begun in July 1983, and delivered at the end of 1985, 30 months later. The first launch is shown as July 1986. The Second Order Platform is a follow-on to the First Order. It shares commonality with the first order (assumes same contractor and uninterrupted production line). Its peculiar development starts 12 months after the First Order. Its delivery is scheduled for July 1987. It is to be launched and joins the First Order already in orbit sometime in November 1987. The Trail Arm has not been scheduled but can be available at the same time or any period after the delivery of the Second Order. It can be delivered within 2-1/2 years from its ATP.

PLATFORM COST ESTIMATES*

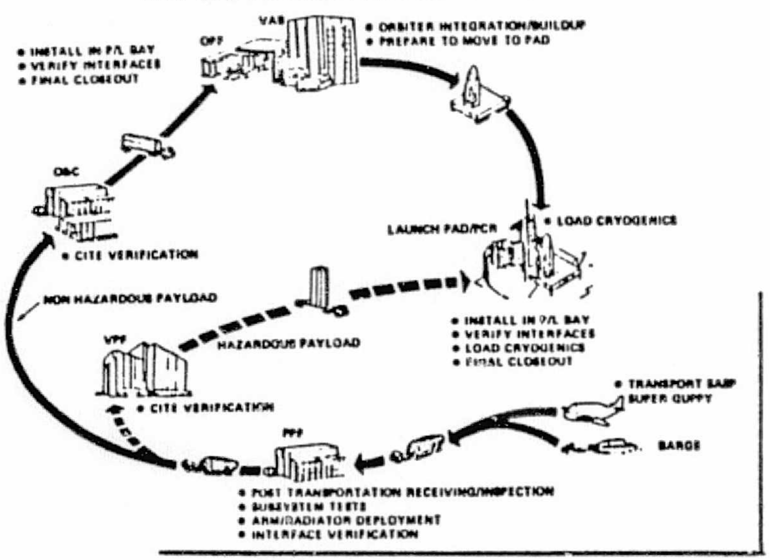
(MILLIONS 1980 DOLLARS)

	First Order			Second Order (F/O to First Order)			Trail Arm (Concurring With Second Order)		
	Non-Recur	Recur	Total	Non-Recur	Recur	Total	Non-Recur	Recur	Total
Program	20.8	9.1	29.9	59.1	25.4	84.5	14.5	6.1	20.6
Prog Mgt	1.0	0.4	1.4	2.8	1.1	3.9	0.7	0.3	1.0
Prog Engr/Integ	1.6	0.7	2.3	3.5	2.1	5.6	1.0	0.5	1.5
Platform Proj	18.2	8.0	26.2	52.8	22.2	75.0	12.8	5.3	18.1
Proj Mgt	(1.1)	(0.5)	(1.6)	(2.6)	(1.5)	(4.1)	(0.7)	(0.3)	(1.0)
Sys Eng/Integ	(2.0)	(0.6)	(2.6)	(4.9)	(1.7)	(6.6)	(1.3)	(0.5)	(1.8)
GSE	(1.2)		(1.2)	(2.6)		(2.6)	(0.8)		(0.8)
Hdwre/Softwre	(12.5)	(6.9)	(19.4)	(29.9)	(19.0)	(48.9)	(7.9)	(4.5)	(12.4)
Integ/Test	(1.4)		(1.4)	(12.8)		(12.8)	(2.1)		(2.1)

*Operations Cost Not Included

KSC GROUND OPERATIONS

SASP KSC GROUND TEST FLOW OPTIONS



- **CAPABILITIES PLANNED**

  PROCESS SASP VERTICAL OR HORIZONTAL
  PROCESS SINGLE AND MULTI-EXPERIMENT PAYLOADS
  PROCESS PAYLOADS THRU VAFB (97° INC)

- **KEY TRADES**

  DEDICATED vs MULTIPLE PPF'S

  KSC vs VAFB INTEGRATION TEST FOR 97° INC PAYLOADS

- **ISSUES**

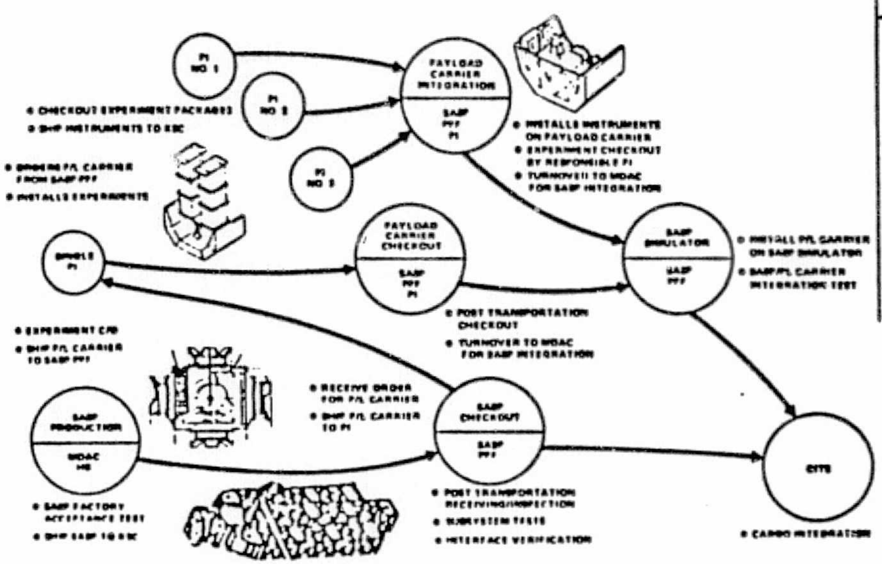
  CLOSED LOOP CHECKOUT
  FACTORY vs LAUNCH SITE C/O

- **EMERGING CONCEPT**

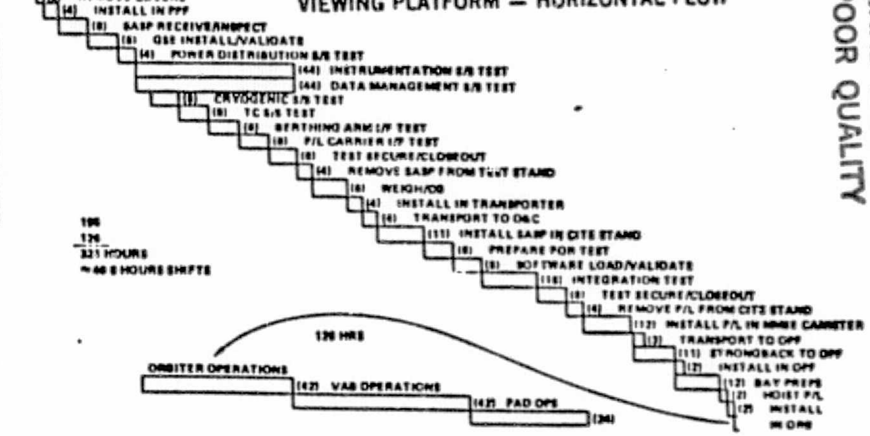
  DEDICATED FACILITY FOR PROCESSING ALL SASP'S AND ASSOCIATED PAYLOADS

  TDY TEAM FOR PROCESSING SASP OR PAYLOADS THRU VAFB

PAYLOAD/CARRIER/PLATFORM FLOWS



LAUNCH SITE OPERATIONS
VIEWING PLATFORM — HORIZONTAL FLOW



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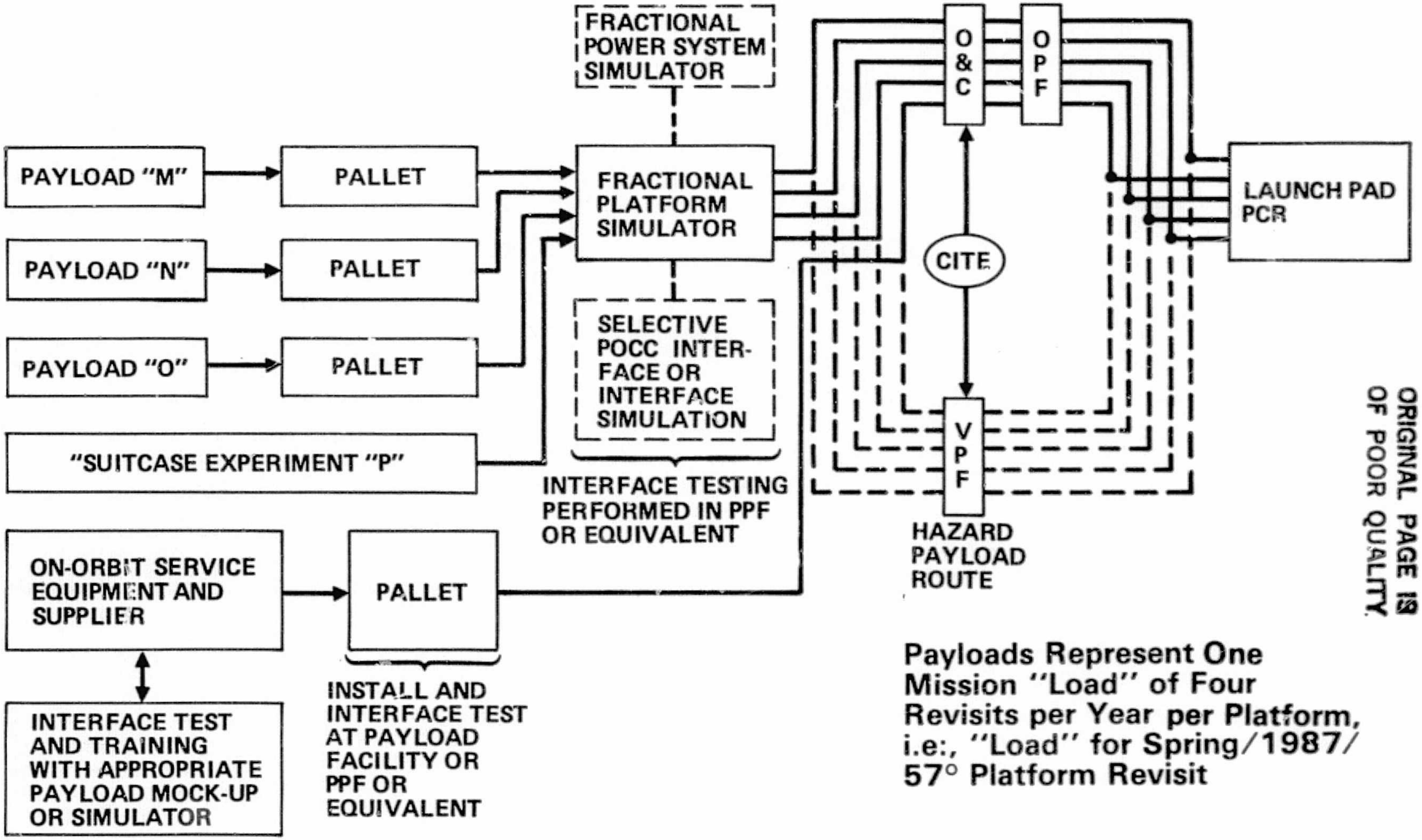
PAYLOAD/PLATFORM INTERFACE VERIFICATION KSC GROUND OPERATIONS

VFE382N



Payloads Represent One Mission "Load" of Four Revisits per Year per Platform, i.e:, "Load" for Spring/1987/ 57° Platform Revisit

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PLATFORM STOWAGE IN CARGO BAY

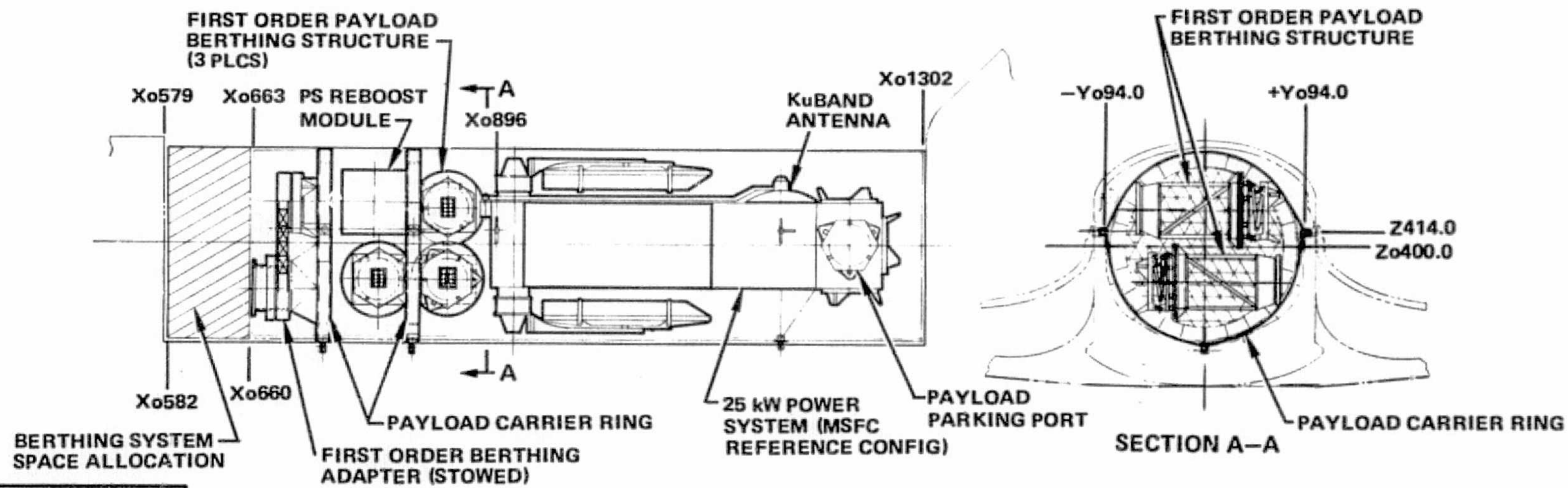
The 1st Order Platform launch pacakge, shown opposite enables the Orbiter to transport all elements required to activate the Platform on the initial launch. In addition to the 25 kW Reference Power System, three payload berthing structures and the PS/Orbiter interface adapter are included in the package. This arrangement is possible with the incorporation of a MDAC designed Payload Carrier Ring. The ring is an X, Y, Z load support structure sized for a 5000 kg payload with a beam stiffened machined isogrid plate for payload mounting. Three berthing structures and the reboost module are supported on one of the two rings with the berthing adapter supported on the second. Space is also available to attach small solar experiments which are to be manually attached to the PS solar array following PS deployment.

The 2nd Order Platform is sized to enable the Platform to be a fixed structural design with all elements integral. Also, the configuration enables installation of the Orbiter OMS kit if mission requirements dictate. A cursory evaluation of transporting the basic 2nd Order with the trail arm extension appears feasible, however, if this launch configuration becomes a program requirement, further investigations may be necessary to determine exact structural dimensions to assure that all elements remain within the Orbiter payload envelope.

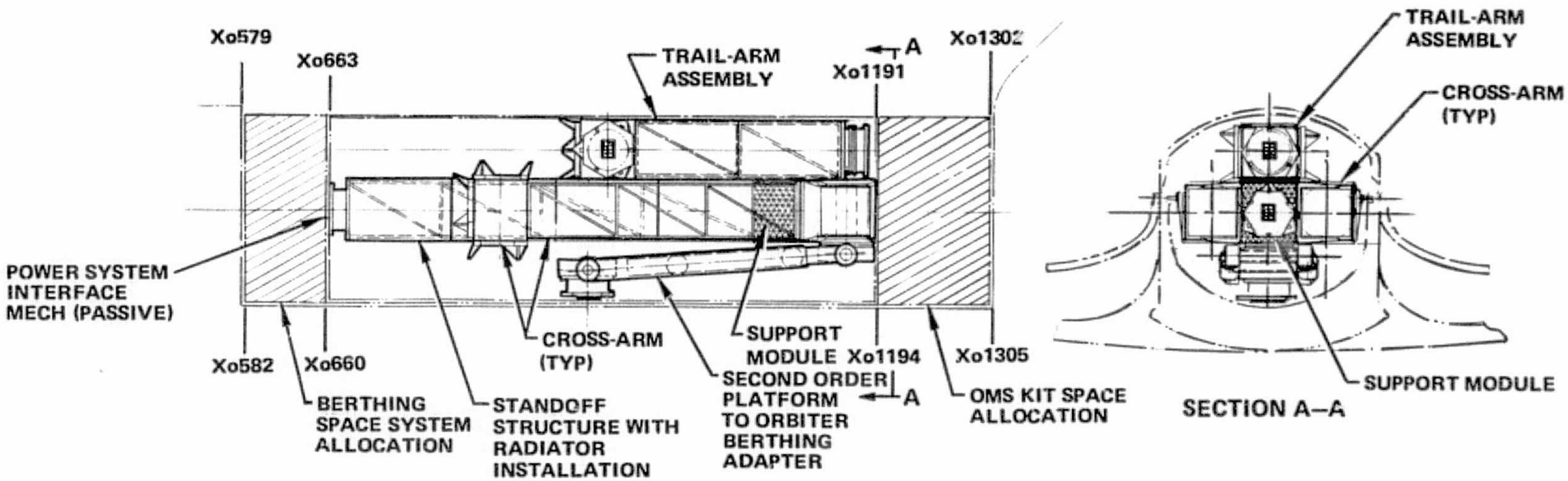
VFG170N

PLATFORM STOWAGE IN CARGO BAY

1st Order



2nd Order



PLATFORM BERTHING EQUIPMENT

Berthing the PS/SASP to the Orbiter requires incorporation of special designed berthing equipment. Three basic elements are required; (1) an Orbiter system, (2) a 1st order platform adapter, and (3) a 2nd order platform adapter. The Orbiter system shown is the concept defined in MSFC's 25 kW Power System Reference Document #PM001 dated September 1979. The active berthing latch shown is a MDAC concept. The 1st order adapter is configured to interface with the PS and the Orbiter system and place the Platform in a position to allow clearance for the RMS and to provide rotation to place payloads within the reach capability of the RMS. An opening is provided to permit EVA access through the berthing system. All initial power and services are provided by the Orbiter until the PS is activated, thereby permitting the PS to incorporate the passive half of the interface.

The increased size of the 2nd Order Platform requires an adapter with additional rotational capabilities and telescoping features. Each adapter is shown as detachable assemblies. However, each system could be an integral part of the Platform, thereby reducing the interface mechanism requirements. In addition, a cursory investigation indicates that the 1st order adapter shown could be used on the 2nd Order Platform with incorporation of a second RMS mounted aft on the Orbiter (+Y) sill.

PLATFORM BERTHING EQUIPMENT

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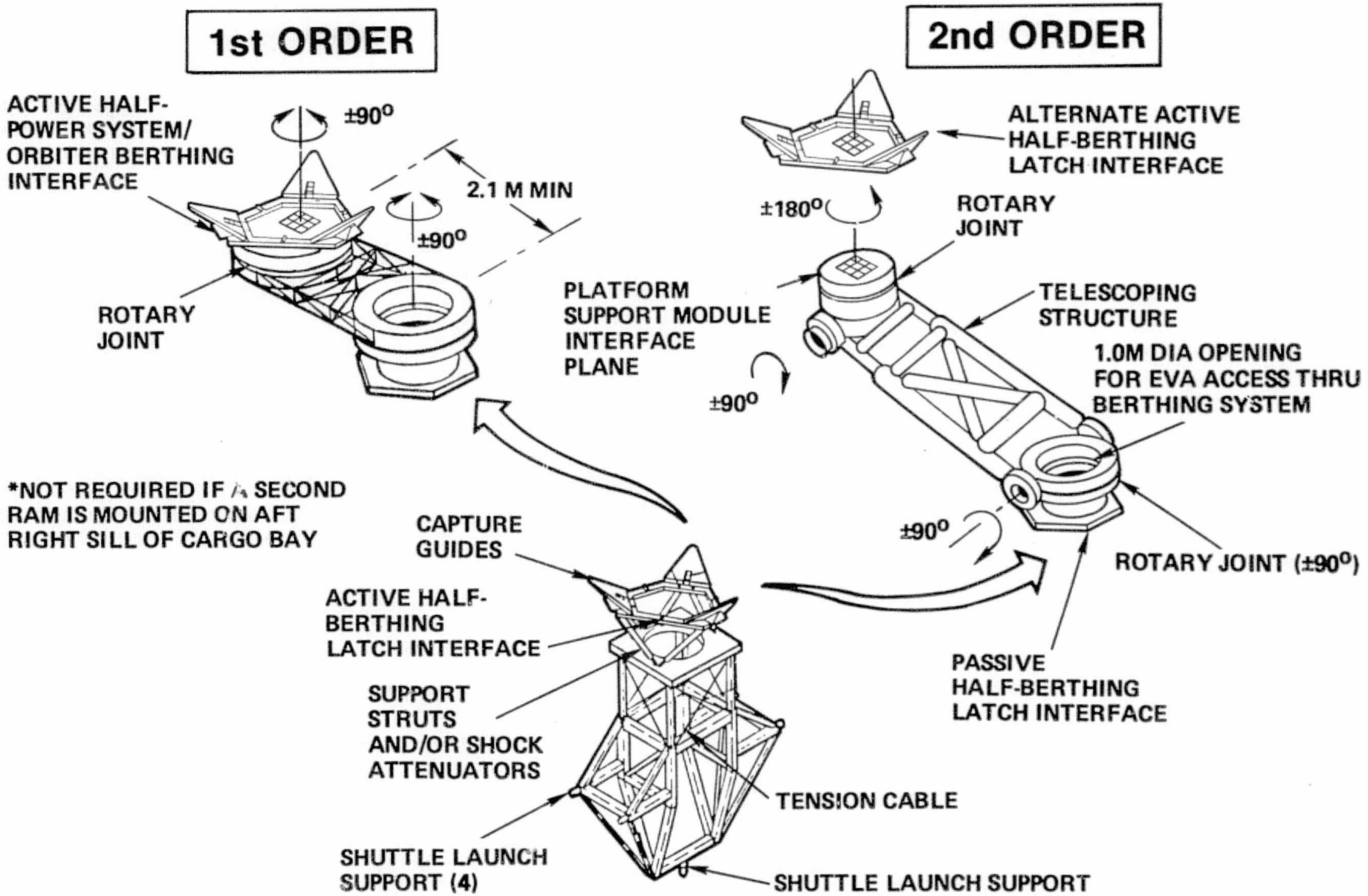

ORBITER BERTHING SYSTEM EXTENDED

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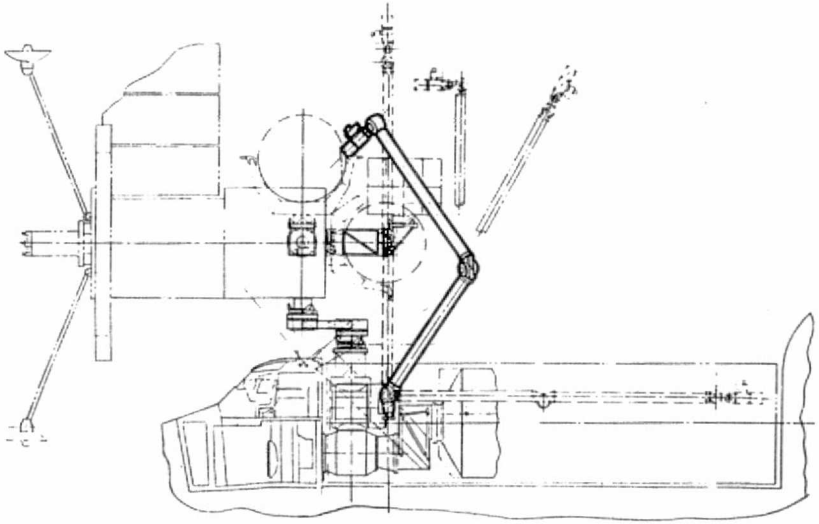
1ST ORDER PALLET ACCESS

Positioning payloads on the (-Y) port of the 1st Order Platform requires the PS be berthed at Orbiter sta Xo 550. This position is necessary to enable the RMS to be deployed to a vertical position prior to being rotated 180° placing end effector in the proper orientation. This position is accomplished with the berthing adapter. From this position, the RMS can access the (-Y) axis and the (+X) axis payloads. Access to the (+Y) axis payloads, the Platform is rotated 90° placing the PS +Y port along the Orbiter (X) axis, thereby allowing the RMS to access the payloads with minimum obstruction. It is recommended that the RMS end effector grapple fitting incorporated on each payload be oriented at 45° to reduce RMS articulation.

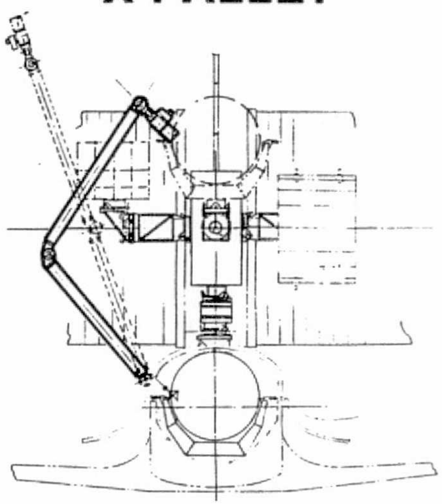
FIRST ORDER PALLET ACCESS

-Y PALLET

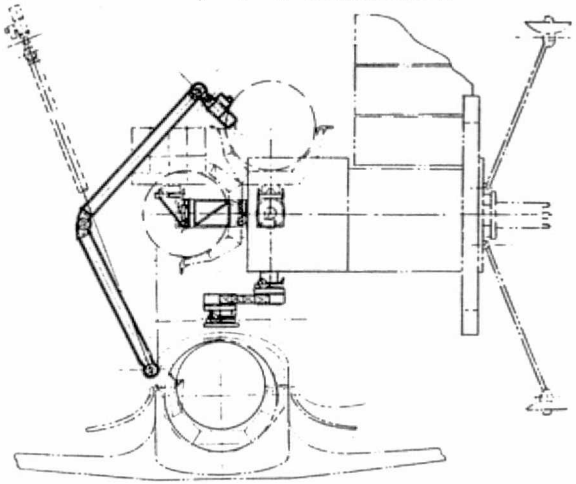


- Dual-Head Berthing Unit Required for RMS Access
- RMS Pre-Rotation Required in Straight-Out Position

X PALLET



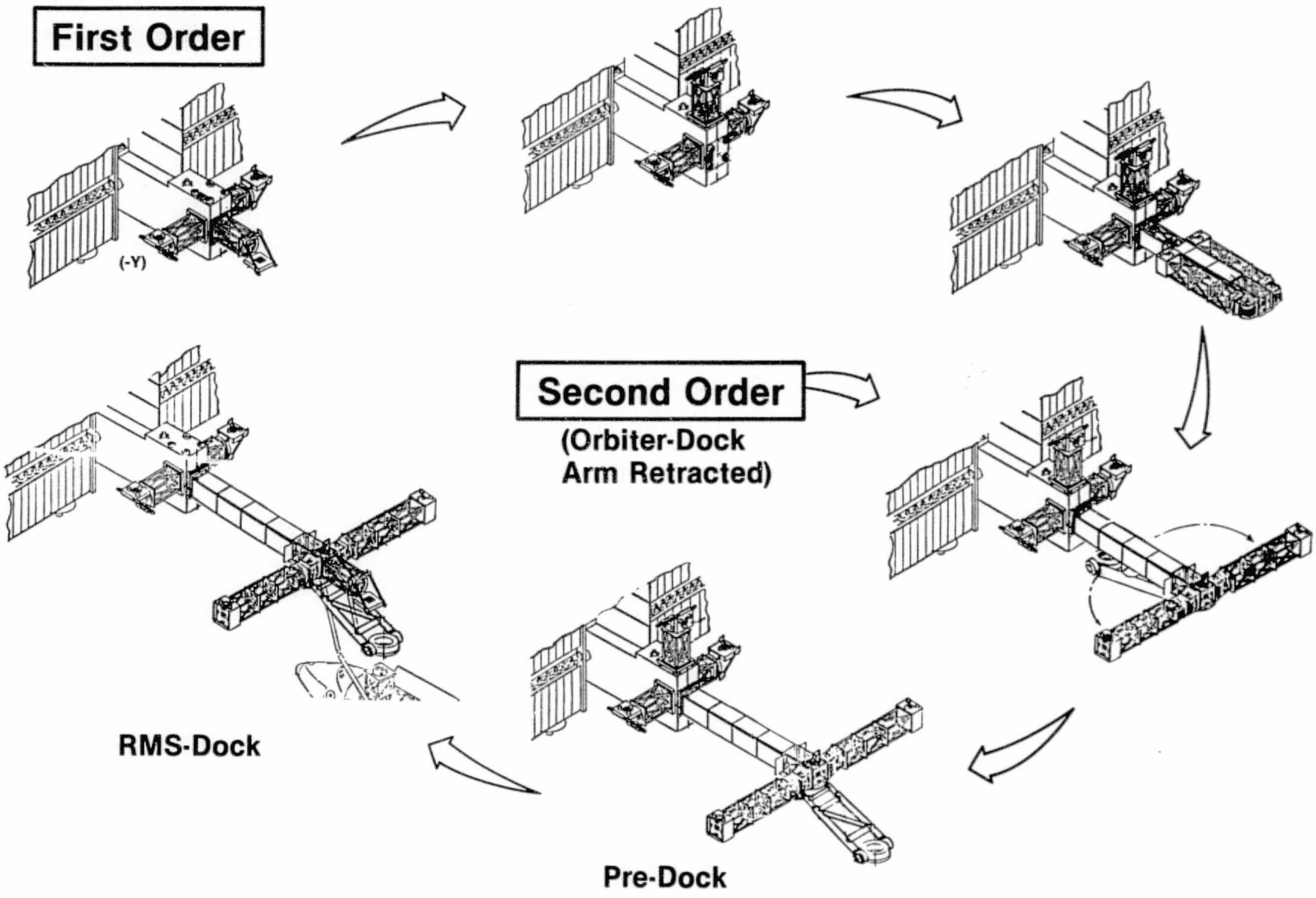
+ Y PALLET



FIRST-SECOND ORDER TRANSITION

The First-Second Order Platform transition assumes that the 1st Order Platform has three payloads, one each on the Y axis, and one on the +X axis. The Orbiter berths to the Power system and places the +X payload on the parking (+Z) port. The 2nd Order Platform is removed from the cargo bay with the RMS and berthed to the Power System's +X port. Following verification of the interface umbilical the RMS is stowed and the cross arms are deployed. With the 2nd order berthing adapter stowed, the Platform is released from the Orbiter. At a safe distance, the adapter is deployed and the Orbiter returns to earth. On a subsequent flight, the RMS captures the SASP and performs berthing operations to join the SASP/Orbiter at the 2nd order berthing adapter system interface. The berthing system rotates the Orbiter into position to remove the payload on the parking port and reposition to the SASP (+X) port. Following verification, experiment payloads are removed from the cargo bay and placed on the Platform.

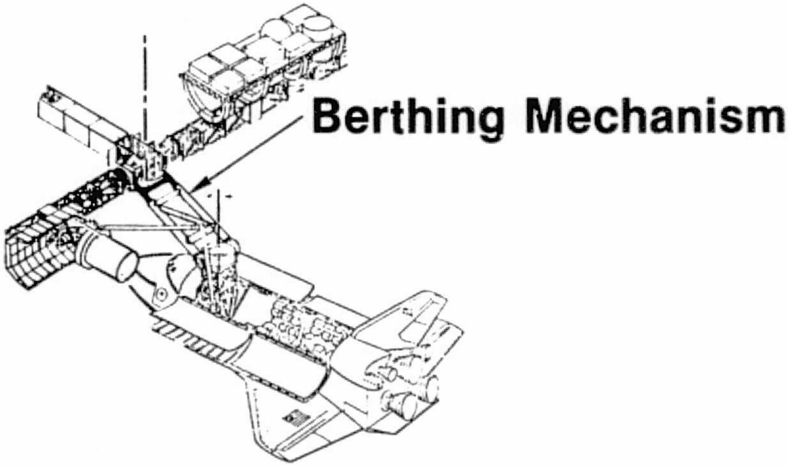
FIRST-SECOND ORDER TRANSITION



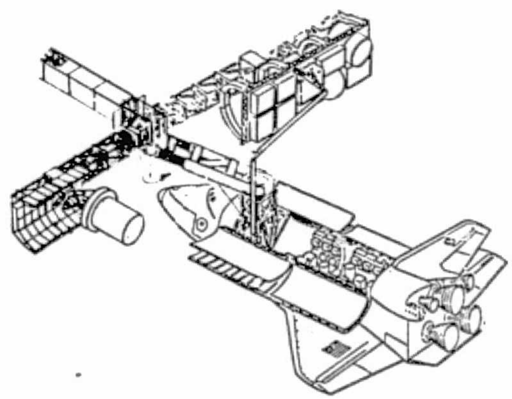
2ND ORDER PLATFORM LOADING

The 2nd Order Platform is configured to accommodate larger payloads which places the payload C.G. outside the capability of the RMS. As a result, the 2nd order berthing mechanism is used to place the Orbiter at discrete positions with the RMS reach envelope. The initial berthing is along the (X) axis. From this position the RMS can reach the inner (-Y) port. A large payload on the (+Y) port requires the adapter to rotate the Orbiter closer to the payload C.G. The outer ports on the extended 2nd Order Platform are accessed by rotating and telescoping the berthing mechanism to place the Orbiter within range for the RMS. Each cross arm is rotated 90° to reduce the berthing system/Orbiter displacement. Use of the 2nd order berthing adapter mechanism places all payloads and PS subsystems within working range of the RMS with a single Orbiter berthing operation.

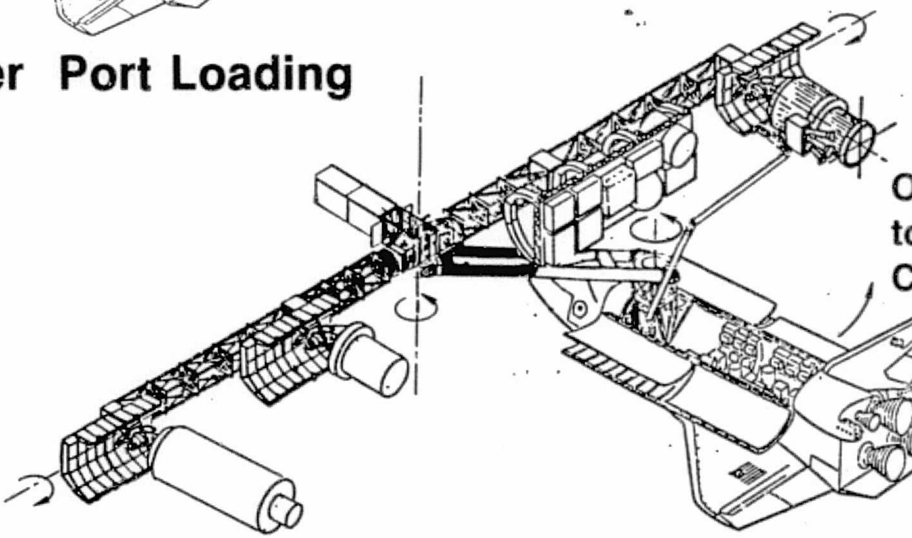
2ND ORDER PLATFORM LOADING



(-Y) Inner Port Loading



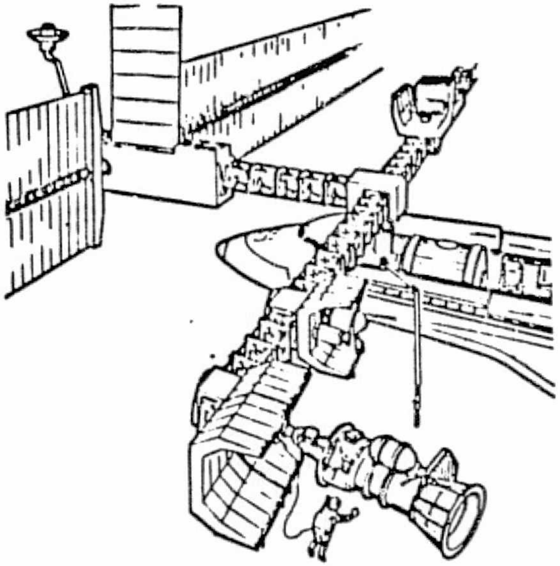
(+Y) Inner Port Loading



Orbiter Can Also Rotate
to Improve RMS Reach
Capability

(+Y) Outer Port Loading

SERVICE AND MAINTENANCE



REQUIREMENTS

- PAYLOADS
- PALLETS
- PLATFORM
- POWER SYSTEM

COMMON TOOLS & TECHNIQUES

- CONSUMMABLES
- SPARES
- MODIFICATIONS
- CALIBRATION

CAPABILITIES

TERRESTRIAL

- ORBITAL HARDWARE ACQUISITION
- SCHEDULING RESOURCE DELIVERIES FOR LAUNCH
- INTEGRATION LOCATIONS
- EXPERIMENTER S&M SUPPORT DURING DESIGN

ORBITAL

- CREW
- SHUTTLE
- AIDS

IN-FLIGHT HARDWARE MODIFICATIONS FOR EXPERIMENT CHANGES

EXAMPLE NO. 3: R-13, LIDAR TEMPERATURE SENSOR

EXPERIMENT CHANGE	HARDWARE CHANGES REQUIRED	RECURRENCE
INCREASED VERTICAL RESOLUTION	REPLACE OR MODIFY THE LASER	ONCE PER TWO YEARS AS STATE-OF-THE ART INCREASES
INCREASED MEASUREMENT ACCURACY	REPLACE OR MODIFY THE LASER, AND MODIFY HIGH VOLTAGE SYSTEM	ONCE PER TWO YEARS
INCREASED MEASUREMENT SENSITIVITY	REPLACE OPTICS, ALSO REPLACE DETECTORS WITH LOWER-NOISE DETECTORS	ONCE PER TWO YEARS

(POTENTIAL MAINTENANCE AREAS)

- LASER FAILURE (LIKELY)
- FAILURE OF HIGH VOLTAGE COMPONENTS (LIKELY)
- DEGRADATION OF OPTICS, REQUIRING REPLACEMENT (LIKELY)
- GENERAL MAINTENANCE, CALIBRATION, AND ALIGNMENT ADJUSTMENTS REQUIRED (DEPENDENT UPON DUTY CYCLE)
- DEGRADATION OF DETECTORS

NEW RING-TYPE PAYLOAD CARRIER

The Spacelab pallet is designed to serve as a standardized structural interface between sortie mission payloads and the Orbiter. On sortie missions it is also the mounting platform for the IPS for those payloads requiring vernier pointing. Since the IPS is not designed to carry the launch loads that heavy payloads impose on the pallet, it must be unlatched from those payloads for launch and engaged on orbit requiring also that the load carrying structure be unlatched from the pointing payload on orbit. These considerations suggest that a simpler, lower cost structural interface with the Orbiter may be desirable for SASP payloads. The MDAC concept for a more suitable platform payload carrier is the ring configuration.

When the Spacelab pallet is used with pointing payloads on sortie missions, latches must be provided between the payload and its support structure which interfaces the pallet, and between the payload and the IPS. Since these latches require hardwire interfaces for power and signals, they complicate the pallet. When the pallet is used for SASP pointing payloads, these latches and interfaces must be retained and berthing latches and umbilical added for interfacing the pallet with the Platform.

With the carrier ring concept shown opposite, all latches between the pointing payload and its support structure are eliminated as well as the latches between the IPS and the payload. Provisions for berthing to the Platform are incorporated in the IPS and the IPS with those provisions is supported from the payload for launch. Because of the loading symmetry it is also more efficient structurally, and therefore, lighter than the Spacelab pallet.

On some sortie missions a number of payloads are supported from a plate mounted on secondary structure on a single pallet. To accommodate payloads of this type on the SASP the beam-stiffened machined isogrid plate shown opposite was configured for use in conjunction with the payload carrier ring shown in the preceding viewgraph.

Berthing provisions are located on the base of the IPS and on one carrier ring supporting the tank cluster. The IPS is berthed on a port on one side of the Platform and the tank cluster is berthed at the port directly opposite. Insulated lines for cryogenic helium run from the powered umbilical at tha tank port to the power umbilical at the IPS berthing interface for delivery of cryogenic helium to the payload.

ADVANCED PAYLOAD CARRIER CONCEPT

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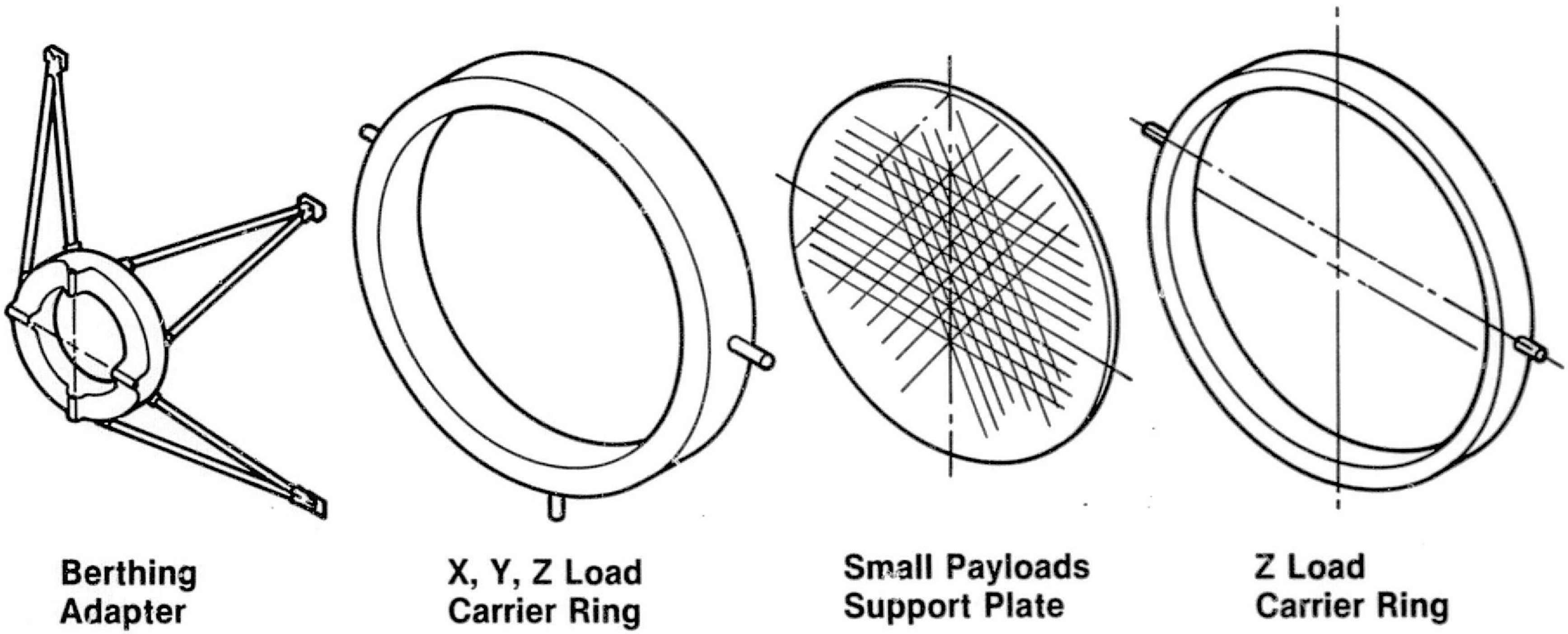

Features

- Low Cost and Lightweight
- Optimized for Payloads Which Do Not Have To Operate in Cargo Bay
- Well-Suited for IPS Mounted Payloads (Example SIRTF)
- Minimum Pointing Restriction for Gimbaled Payloads
- Minimum Weight on Platform

STRUCTURAL MECHANICAL DEMONSTRATION TEST ARTICLE

A preliminary flight test which combines all of the critical operational mechanisms and structures are combined together to verify the ground test and analysis. All of the test components and equipment will be launched on one (1) pallet. The pallet should also be modified to be bottom mounted with a passive berthing port to match the active berthing port on the test hardware. The test system will receive its power from the Orbiter. The Orbiter will be flown in a similar mode to the actual SASP flight to have a similar thermal gradients.

STRUCTURAL/MECHANICAL DEMONSTRATION TEST ARTICLE

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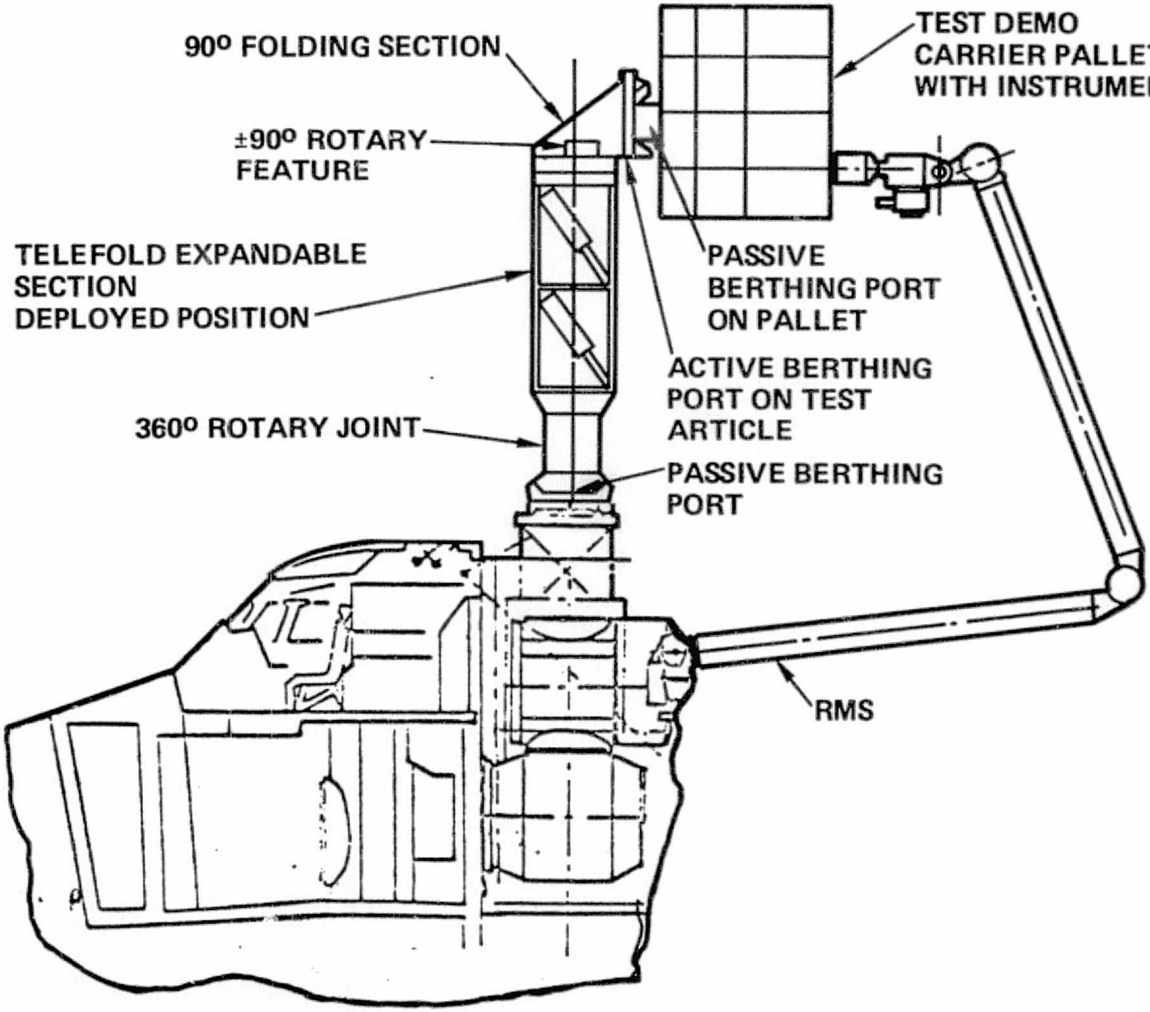

- **All Test Components Will Be Stowed and Launched on One Pallet**
- **Test Sequence**
  - **Unload Test Article from Pallet with RMS and Berth to Orbiter Berthing Adapter**
  - **Unload Test Demo Payload Carrier Pallet With RMS and Berth to SASP Structure Berthing Port**
  - **Deploy Expandable Truss Structure**
  - **Operate and Instrument Components per Performance**

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NEW CANDIDATE PLATFORM CONCEPT

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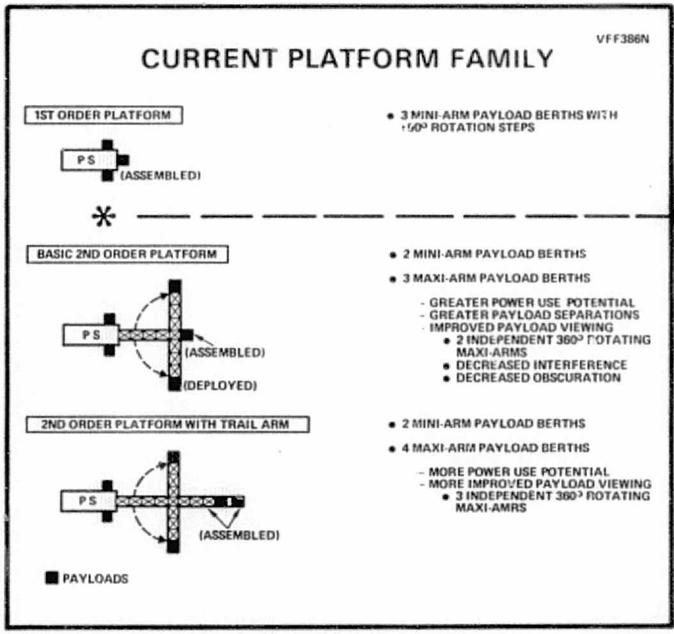
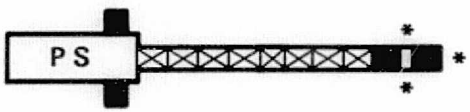
(RECOMMENDED FOR FOLLOW-ON STUDY)



- DECREASE AMOUNT OF GROWTH BETWEEN STEPS
  - INTERIM STEP WITH ONLY 1/3 OF 2ND ORDER PLATFORM
  - REDESIGN FOR GROWTH VIA ADDITION OF IDENTICAL UNITS
  - SIMPLER BASIC DESIGN
  - LOWER COST INITIAL STEP AND TOTAL PROGRAM
- MODULARIZE TO ECONOMIZE

ULTRA-BASIC 2ND ORDER PLATFORM



(ASSEMBLED)

- 2 MINI-ARM PAYLOAD BERTHS
- 3 MAXI-ARM PAYLOAD BERTHS (ONE INDEPENDENT 360° ROTATING
- (MAXI-ARM)

*ADD IDENTICAL ARMS FOR GROWTH

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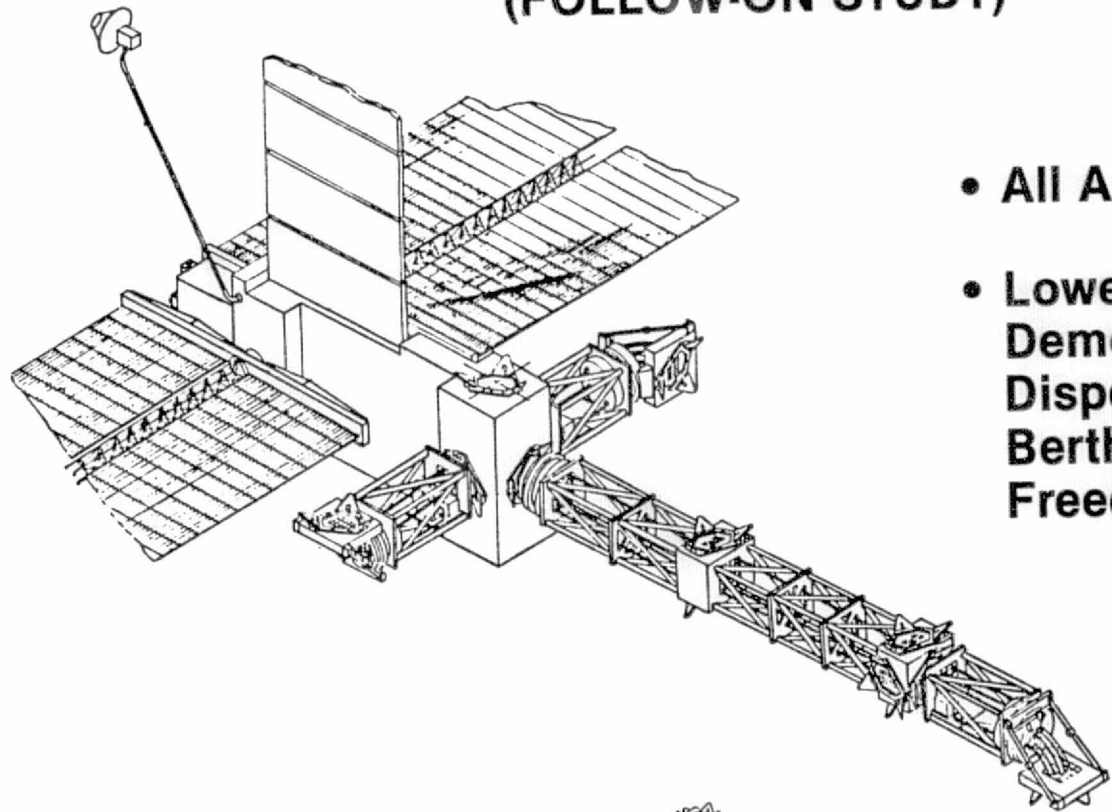
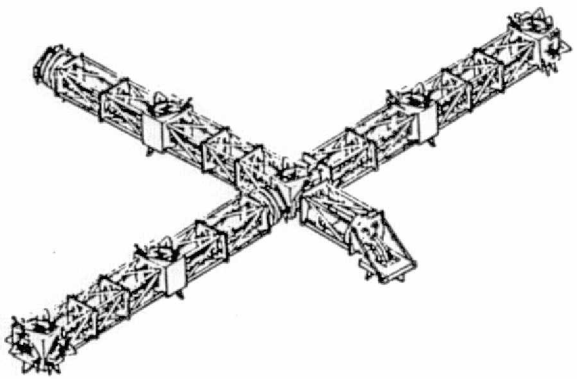
NEW PLATFORM CONCEPT
(FOLLOW-ON STUDY)



- All Arms Identical
- Lowest Cost Initial Demonstration of Dispersed Payload Berthing for Viewing Freedom



- Three Identical Arms Equal Original Basic Folding Arm Concept

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FLIGHT PERFORMANCE DYNAMICS, VIEWING AND STABILIZATION

DICK HAUVER

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SYSTEM LEVEL SUBJECTS ADDRESSED

During the course of the SASP a wide range of system level topics have been addressed as shown on the facing chart (operations, configuration development, and costs excluded). The purpose of such a broad scope was to identify any problems that might compromise the viability of the SASP concept. When problems or uncertainties were encountered an indepth assessment was made.

SYSTEM LEVEL SUBJECTS ADDRESSED

REQUIREMENTS

- PAYLOAD REQT'S
- ORBIT REQT'S
- ORBIT CONSTRAINTS
- FUNCTIONAL ALLOCATION
- PLATFORM SIZING
- SCENARIO ACCOMMODATIONS

VIEWING

- GENERAL CAPABILITY
- SIZE SENSITIVITY
- MINI-ARM TRADES
- PROSPECTS FROM
  - TBAR
  - 1ST ORDER
  - 2ND ORDER
  - POWER SYSTEM
- EXPERIMENT PROGRAM

STRUCTURES & DYNAMICS

- MATERIALS
- EXTERNAL DISTURBANCES
- PAYLOAD DISTURBANCES
- NASTRAN
- DYNAMIC ENVIRONMENT
- DAMPING
- TORQUE SHAPING
- AUXILIARY POINTING SYSTEMS
- THERMAL TRANSIENTS

FLIGHT MECHANICS

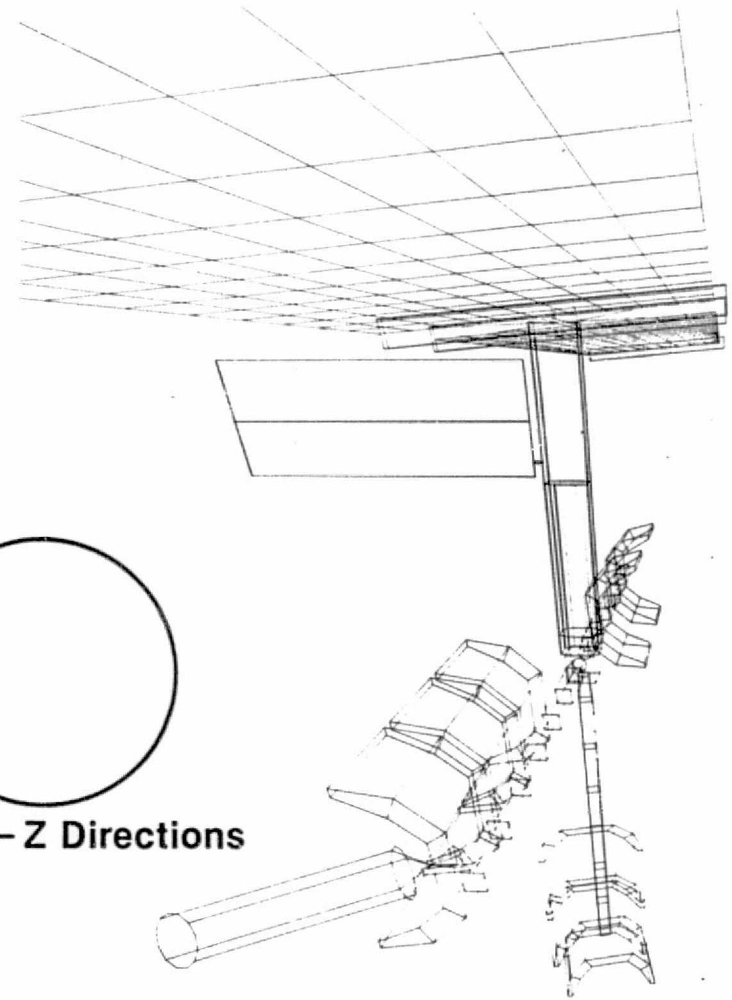
- ORBITER PERFORMANCE
- ORBIT TRANSFER
- ACCELERATION LEVELS
- ORBIT KEEPING
- ORIENTATION

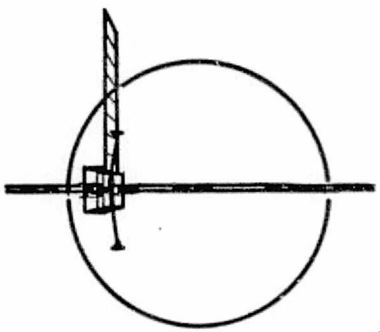
VIEWING ANALYSIS

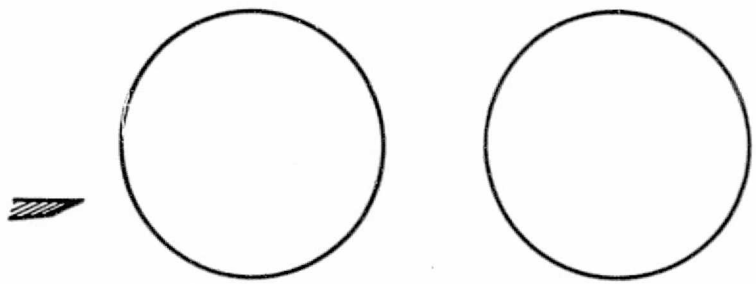
One of the primary advantages provided by the Platform is simultaneous viewing provided multiple payloads. In order to assure this capability a variety of viewing analyses and evaluations of candidate configurations and design options were performed. The primary tool used in these analyses is the MDAC computer graphics dedicated Engineering Work Station with its interactive 3-D graphics capability.

COMPUTER GRAPHICS FOR PLATFORM VIEWING ANALYSIS

- PAYLOAD VIEWING PERSPECTIVES WITH RESPECT TO TIME
- AREA OF INTEREST COVERAGE TIME CONSUMPTION
- INTERFERENCE ZONES: OBSCURATION, I-R BACK-LOADING, EARTH DISC, ETC
- VEHICLE ATTITUDE SELECTION







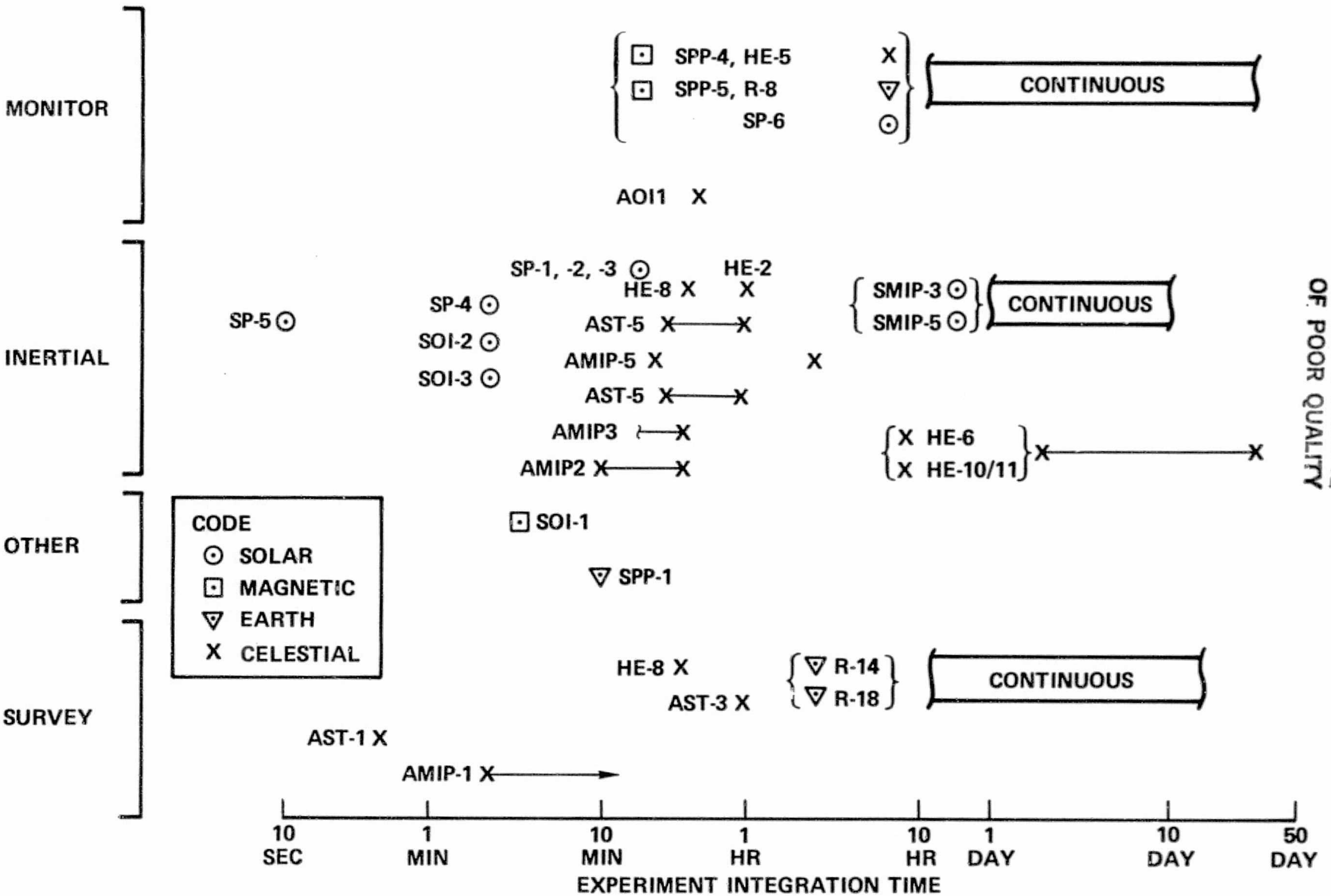
+Z Direction   +X and −Z Directions

−X Direction   Views from Inner Pallet

INTEGRATION TIME REQUIREMENTS

MDAC has gotten viewing requirements from three sources: (1) the NASA-provided precourser experiment studies; (2) the companion experiment definition study performed by TRW; and (3) suggestions from the SASP User Review Group. The opposite chart, categorizing the viewing experiment integration time requirements, is representative of the quantitative information available.

INTEGRATION TIME REQUIREMENTS



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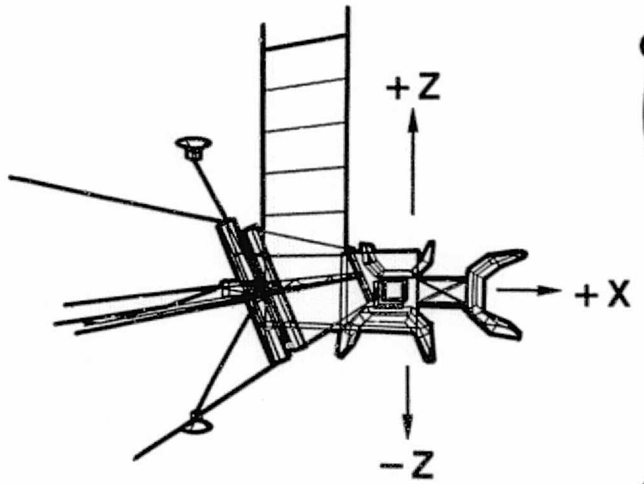
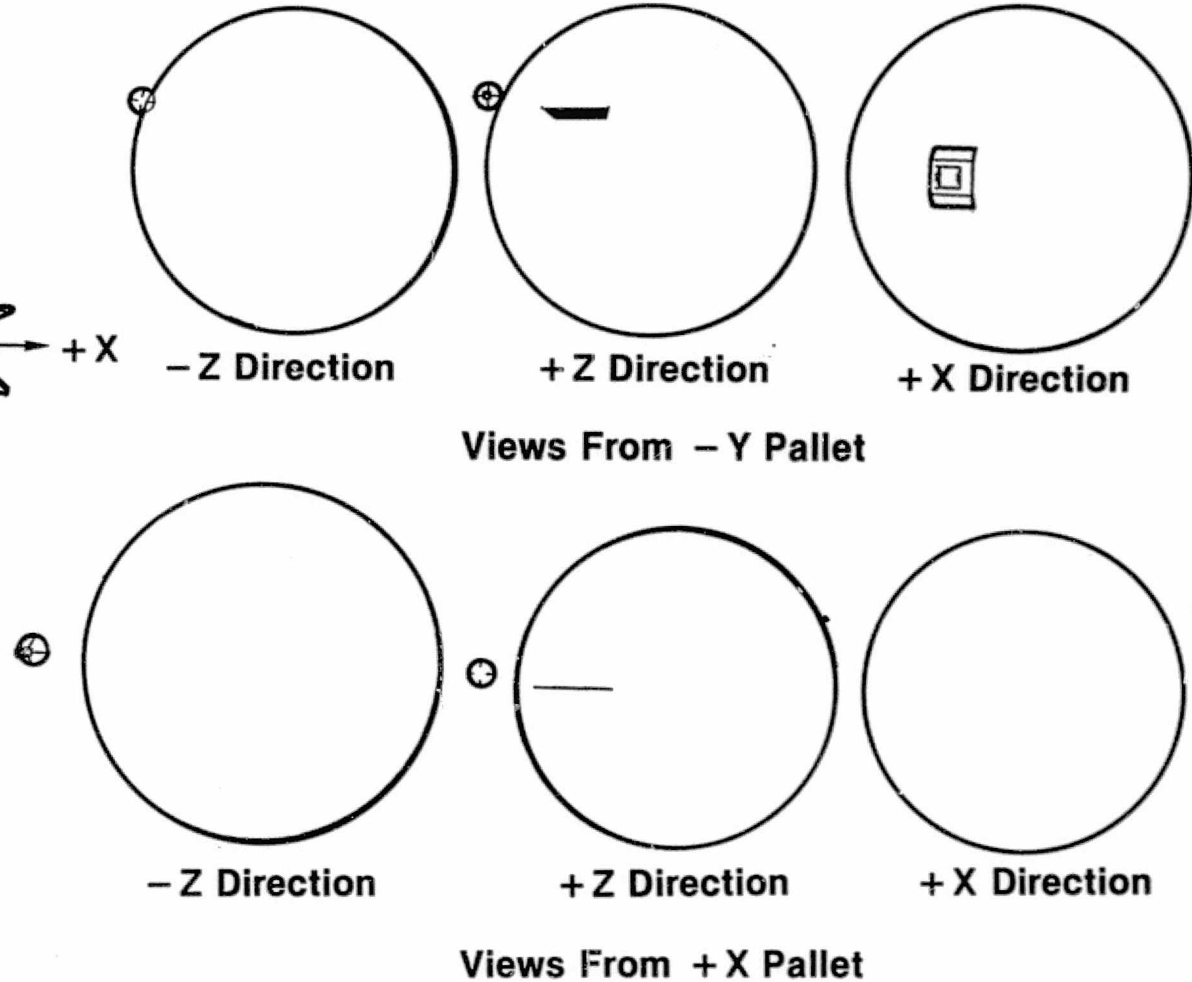
FIRST ORDER PLATFORM VIEWING

Each of the three pallet berthing locations on the 1st Order Platform has the capability to point the pallet in three directions: -Z, +Z, and +X. The views from the X or trailing location and from one of the two symmetrical side locations are shown for each of these three directions. As shown, there is obscuration of the potential 60° gimbal angle in the +Z direction by the radiator. Viewing in the -Z direction is clear. From the side location +X viewing is partially obscured if a pallet is at the trailing or aft location.

FIRST-ORDER PLATFORM VISIBILITY





- First Order Platform
- Three Payload Pallets
- 60° Gimbal Angle FOV

VIEWING EXPERIMENT PROGRAM

NASA/MSFC has provided MDAC with an example astronomy viewing program for a single instrument. This program is summarized on the accompanying page. The first 24 observation targets require consecutive viewing from #9 where 30 minutes of continuous observation is required once a day for 120 consecutive days to #21 where 30 minutes observation is needed every orbit for six consecutive days. The last 18 targets do not require consecutiveness but are extensive, each requiring 30 minutes observation on 400 distinct orbits.

MDAC has chosen this experiment program to make sample comparisons with and provide at least one realistic measure of viewing performance.

VIEWING EXPERIMENT PROGRAM

TARGET PARAMETERS

NUMBER	RIGHT ASCENSION (DEG)	DECLINATION (DEG)	NUMBER OF CONSECUTIVE DAYS	ORBIT OBSER. FREQUENCY	MINUTES PER OBSERVATION
1	18.94	-[illegible]3.71	16	1	10
2	135.06	-40.36	36	1	30
3	169.76	-60.35	9	1	10
4	234.66	-52.23	15	1	30
5	245.01	35.42	7	1	5
6	83.95	26.29	60	3	30
7	169.75	-61.59	60	3	30
8	176.39	-61.93	60	3	30
9	185.96	-62.49	120	16	30
10	189.78	-59.93	60	3	30
11	194.53	-61.33	60	3	30
12	246.81	-67.35	5	1	10
13	262.24	-24.71	30	3	30
14	58.06	30.90	6	1	25
15	82.88	21.98	3*	1	MAX
16	18.81	63.48	97	8	30
17	83.19	-66.40	11	1	20
18	229.20	-56.99	67	4	5
19	253.28	-40.75	30	3	30
20	255.14	-37.77	14	1	20
21	273.74	49.85	6	1	30
22	229.12	35.07	17	3	20
23	307.66	40.79	68	1	5
24	325.65	38.09	45	4	10
25	78.12	-40.10	NO CONSECUTIVE REQUIREMENT. EACH TO BE OBSERVED ON A TOTAL OF 400 DISTINCT ORBITS.		30
26	242.22	-52.30			30
27	249.23	-53.65			30
28	254.73	-29.87			30
29	255.67	-42.97			30
30	262.17	-33.80			30
31	262.53	-33.35			30
32	263.83	-44.42			30
33	265.72	-29.50			30
34	265.61	-30.00			30
35	265.97	-28.87			30
36	266.70	-37.04			30
37	275.12	-30.39			30
38	279.37	4.99			30
39	282.59	-8.77			30
40	286.48	0.09			30
41	289.04	-5.33			30
42	321.89	11.95			30

*REPEAT SEQUENCE TWICE SEPARATED BY AT LEAST 90 DAYS.

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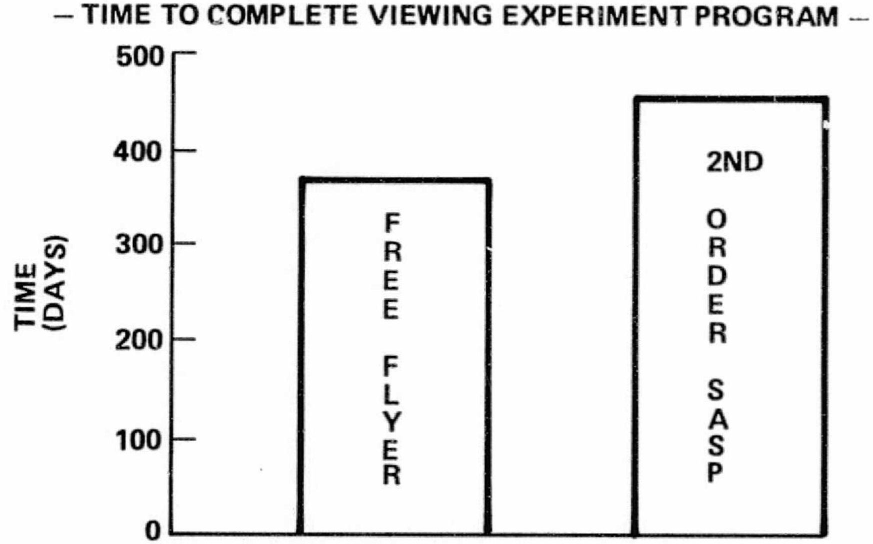
PERFORMANCE COMPARISON

MDAC has developed a computer program that simulates the viewing experiment program. Using this computer program and the MSFC experiment program presented in the preceding chart, several comparisons were made. Near optimum experiment schedules were developed for both free flyer and the 2nd Order SASP configurations. Restrictions placed on the SASP by its multiple viewing capability costs only 80 days of experiment time.

Also shown is the viewing pattern over a representative orbit. On a map of the targets the observations of 18, 24, and 6 are performed. Areas unviewable due to the solar disk and to the 60 degree instrument gimbal angle assumption are shown for an X-POP, Y-PSL orientation.

PERFORMANCE COMPARISON

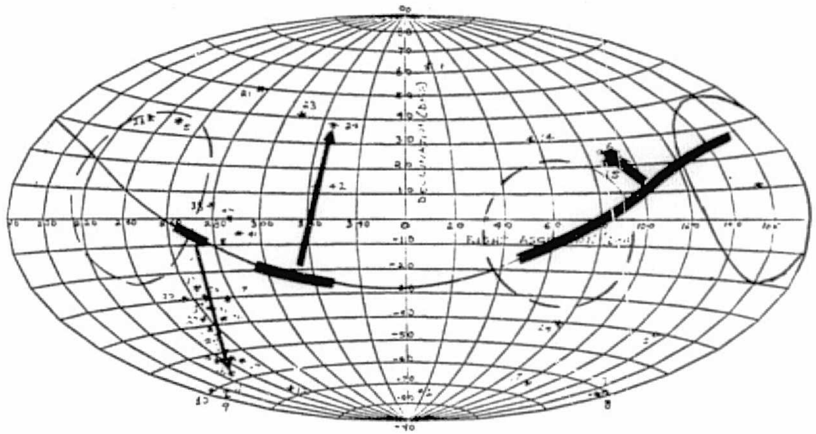


ASSUMPTIONS:

- ORBIT
  - i = 28.5°
  - h = 235 n.mi
- OBSCURATION
  - 30° SOLAR RADIUS
  - 15° EARTH EXCLUSION ZONE
  - 15° SPACECRAFT EXCLUSION ZONE
- FREE FLYER
  - NO RESTRICTIONS
- SASP
  - INSTRUMENT ON CROSS ARM
  - 60° INSTRUMENT GIMBAL ANGLE

EXAMPLE

2ND ORDER PLATFORM
• 1ST ORBIT — 156TH DAY



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PLATFORM SIZING

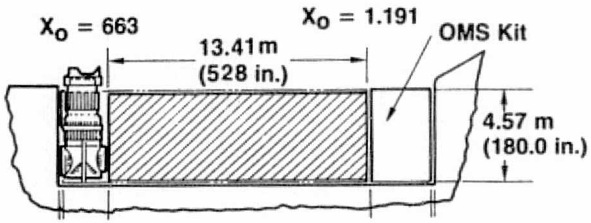
Platform sizing requirements were developed and are summarized in the Figure. These reflect the Orbiter payload bay constraints, the desire to avoid payload to payload and payload to solar array interferences, the desire to satisfy the maximum number of candidate payloads and the desire for both configuration commonality and growth capability. The initial assumption was that either gimbal locks or software programming could avoid interferences; however, frequent payload loading changes would make this approach subject to frequent change and possible safeguard failure. Consequently, analysis focused on selecting a payload length limit which would assure payload/Power System (PS) clearance. Subsequent study should re-examine this decision as Platform and PS designs are further developed and representative payload requirements are affirmed.

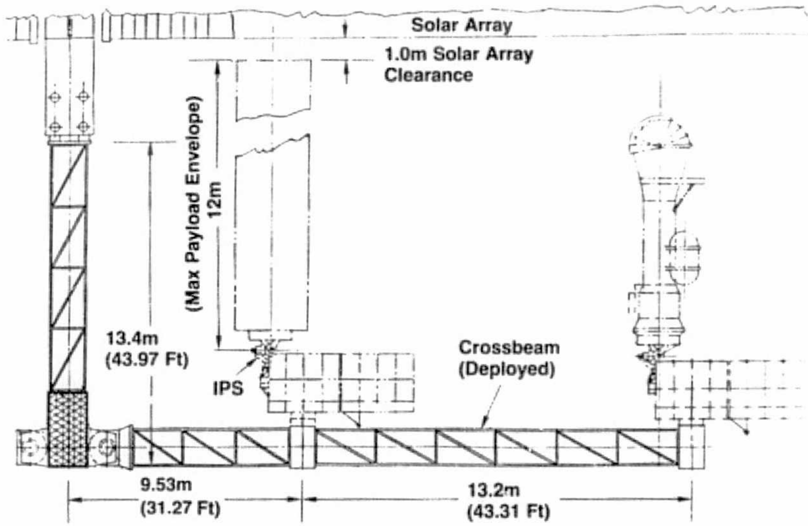
The resultant design features a 13.4 m standoff distance capable of accommodating a 12 meter instrument without providing a collision risk with the solar panels. The port separation distance of 13.2 meters on each cross arm results from an analysis of adjacent payload size combinations and their motion envelopes. A similar analysis identified a separation distance of 9.5 m from the center line to interior port.

SECOND ORDER PLATFORM SIZING

- Fit Platform Into Payload Bay With OMS Kit and Docking Adapter (13.4 Meters)
- Prevent Collision Between Payloads and Solar Arrays
- Prevent Collision Between Adjacent Payloads
- Satisfy the Maximum Number of Payloads
- Minimize Structural Free Play
- Maintain Commonality Between Configuration Options
- Maintain Growth Option

Maximum Envelope With Docking Module and OMS Kit





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SECOND ORDER PLATFORM SIZE SENSITIVITY

Separation Distance (m)	Percentage of Payload Lengths Accommodated* (Lengths: 38%≤3m, 28% 3-5m, 17% 5-12m, 7%18-20m, 10%≥20m)		
	Solar Panel Avoidance	Adjacent Payload Avoidance (120° IPS Sweep Cone)	Berthing with RMS
7.5	65%	(Inner Ports) 72% (Two 8m Payloads)	100% (Both Inner Ports)
9.5	75%	(Design Point) (Inner Ports) 75% (Two 10m Payloads)	(Design Point) 100% (Both Inner Ports) (Max RMS Reach)
11.0	80%	83% (Two 12m Payloads)	1 Inner Port Only
13.5 (Max Solid Arm Length/Cargo Bay; OMS and Docker)	(Design Point) 83% (12m Payload)	(Design Point) Outer Ports 70% (Two 7m Payloads)	0
21.5	90%	83% (Two 12m Payloads)	0

*Payload Diameters and Shape also Influence Platform Sizing

SOLAR PANEL SHADOWING

One Power System interface issue addressed during the study is the amount of solar panel shadowing due to the presence of the SASP. Shown are views of worst case shadowing taken from the SASP graphics computer program. For this situation the shadowing amounts to 3% for the 1st Order SASP and 6% for the 2nd Order SASP. These numbers are without payloads. Adding large antenna or telescope could provide significantly more shadowing. However, shadowing is orientation dependent and may be limited through scheduling.

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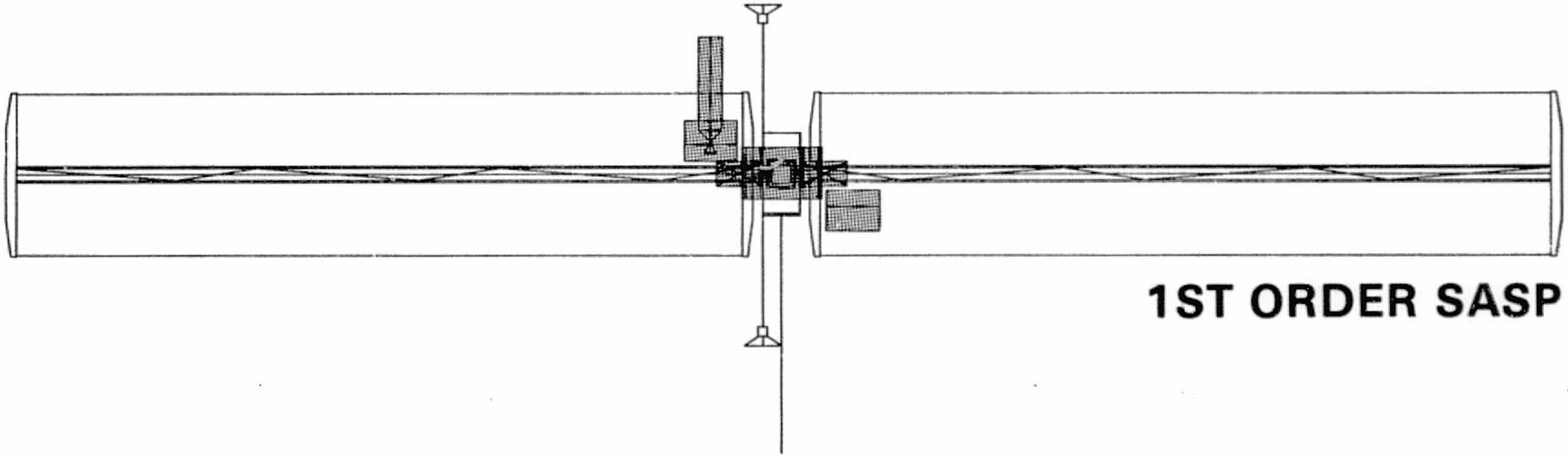
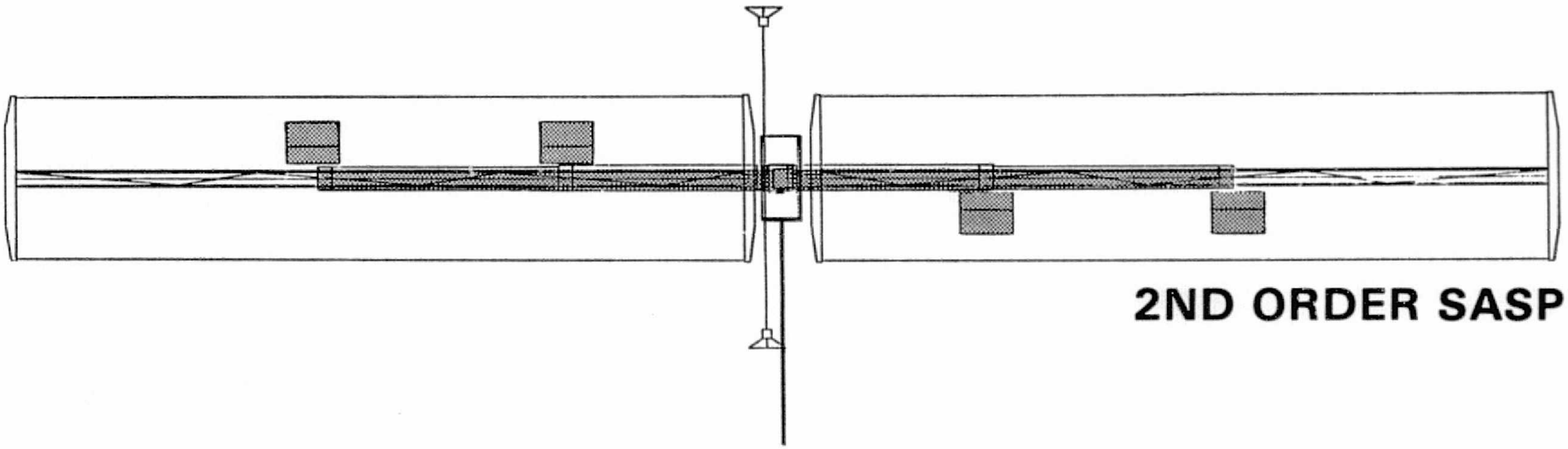
SOLAR PANEL SHADOWING
— WORST CASE —



1ST ORDER SASP



2ND ORDER SASP

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Platform Arm Compaction Comparison - The basic module is comprised of two berthing ports approximately 20 ft. on center, each concept was reviewed for its compaction characteristics, the maximum compaction ratio of 9.5:1 was accomplished with the MDAC telefold expandable concept, each concept has its unique features. The ideal concept will be an expandable arm with minimal joints and structural configuration that will meet the maximum rigidity, reliability, and material to minimize thermal distortion, the MDAC telefold was selected.

Cost/Structural Trade - This chart lists the key points in the comparison of the three structural concepts investigated for the platform arms. The costs shown are the direct design, test, and fabrication costs for one section of each configuration. This required some normalization to include comparable functions. The major differences are structural but the fluid lines and wiring harnesses are also impacted. The cost of the fluid lines and wiring harnesses themselves are not included but the additional mechanisms for spooling the lines are included.

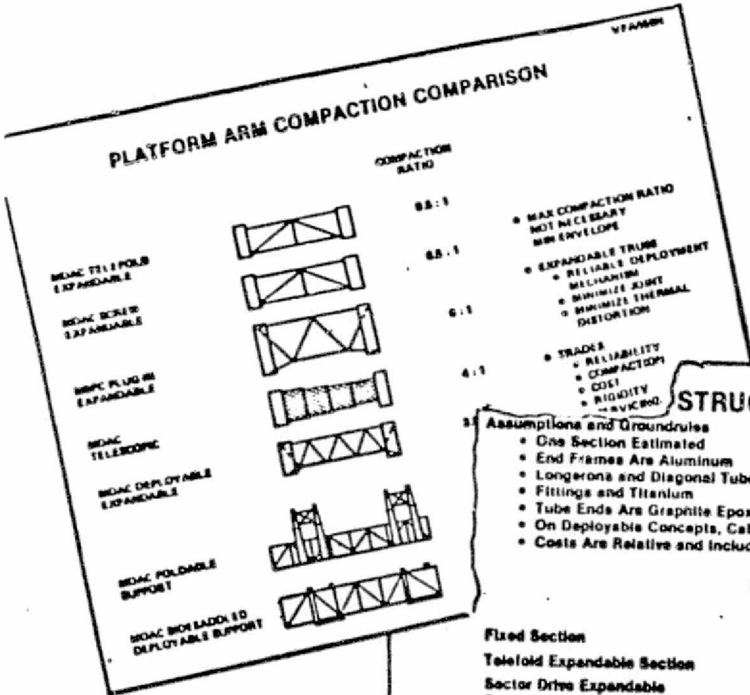
In addition to the costs of the individual sections, there are other impacts when several of the sections are combined into an arm. The rigid sections take more Shuttle space and a hinge joint (costing approximately $150,000 to fabricate) is added to the arm.

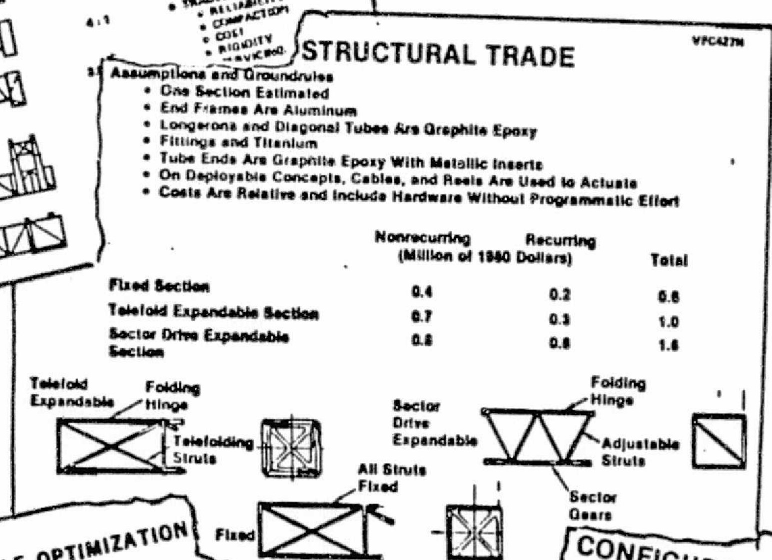
Fixed-Truss Structural Module Optimization - This chart summarizes the fixed truss absolute stiffness, specific stiffness, and stiffness/complexity ratings of the five candidate module configurations. It is seen that module (IIIA) has the best absolute stiffness total rating while module (IA) has the best specific stiffness and stiffness/complexity total rating. On this basis, configuration (IA) could be considered the optimum structural module configuration. However, even though module (IB) has the lowest absolute and specific stiffness total ratings, preliminary conservative calculations show that the stiffness provided is sufficient to satisfy the $f_n \geq .1$ Hz requirement for the SASP platform. This consideration, combined with configuration (IB)'s second best rating on a stiffness to complexity basis and the fact that on an absolute basis configuration (IB) is least complex resulted in the selection of configuration (IB) as the optimum structural module configuration for the SASP platform arm.

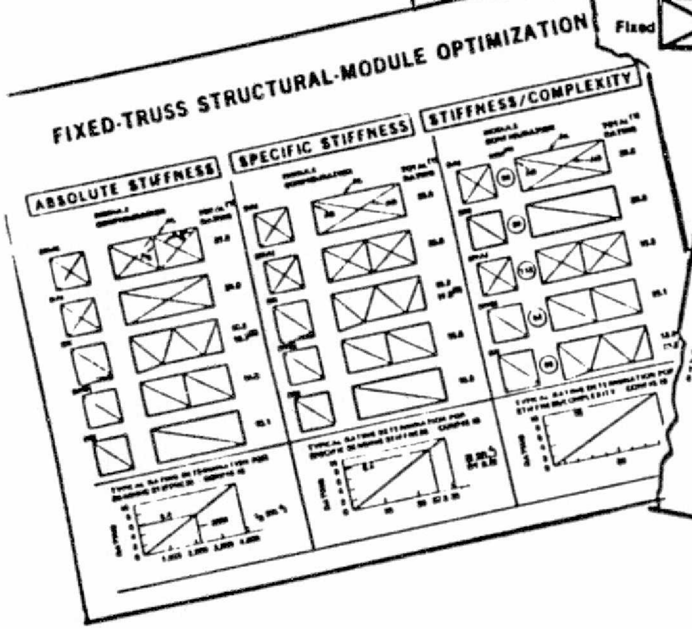
Structural Configuration - Candidate concepts were reviewed and narrowed down to three basic concepts; fixed, telefold expandable, and sector drive expandable. The trades on cost, reliability, servicibility, compaction, and stiffness resulted in the selection.

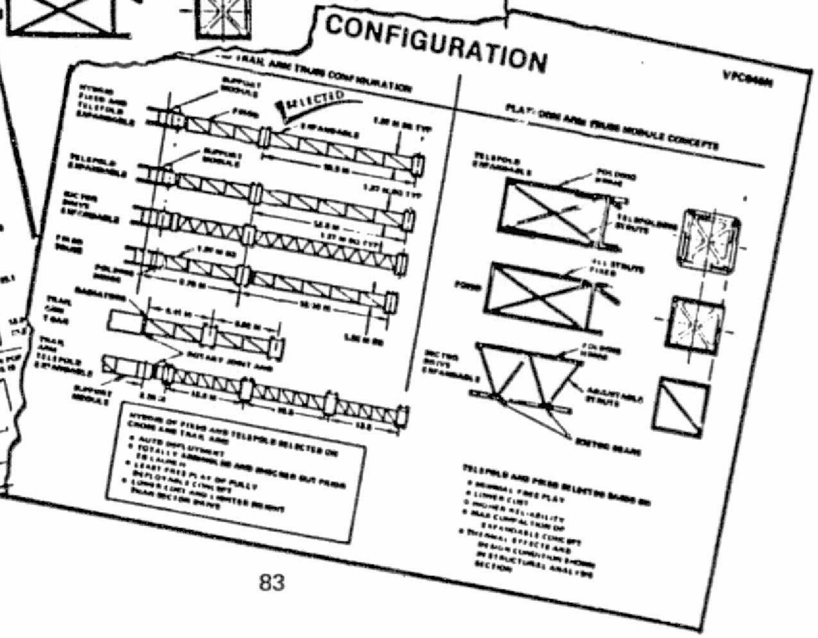
The all fixed truss concept was not selected due to greater dynamic deflection based on a smaller moment of inertia. This resulted from the launch envelope. The fixed truss also has a shorter distance between the payloads. The sector drive was also not selected due to cost, weight, complexity, reliability, and greater free play.

The following structural configuration was selected for: (1) Cross Arm - fixed truss for standoff and inner truss on cross arm and telefold expandable for the outer truss on the cross arms; and (2) Trail Arm - consists of fixed truss (radiators mounted).









MATERIAL/STRUCTURAL ANALYSIS

SELECTED APPROACH

- MATERIAL – STRUCTURE
  - ZERO CTE GRAPHITE/EPOXY (BARE)
  - HYBRID FIXED/DEPLOYABLE
  - STRUCTURAL MODULE IB

  - SATISFIES $f_n > 0.1$ Hz
  - PROVIDES MINIMUM COMPLEXITY
- TUBING SIZE:
  2-5/8 IN. O.D. X 1/8 IN. THICK

Configuration Tolerance Study - These tables show the various structural configurations which were analyzed for the total MFG, assembly, free play, and thermal error between the Power System interfaces through the Platform to the pallet interface. Various combinations of fixed and expandable truss concepts were analyzed and the overall results indicate that the error is relatively small.

Concept "B" was selected based on payload accommodation, servicing, and compaction. Concept "E" had the smallest overall tolerance but did not meet the spacing criteria due to compaction overall configuration for launch. The total SASP accuracies will be summarized in the Attitude Control section.

Preliminary Estimate of Platform Distortion - This figure shows the selected mass distribution used for the cross arm configuration. To estimate structural distortions for the noted spacecraft maneuver conditions. The distortions are based upon the following procedure:

1. Assume structure is a rigid body and calculate accelerations at the noted masspoints for the yaw, pitch, and roll conditions.
2. Using F = ma, calculate forces at mass points.
3. Calculate static rotations at point (2) relative to point (1).
4. Increase static rotations by factor of 2 to approximately account for dynamics.

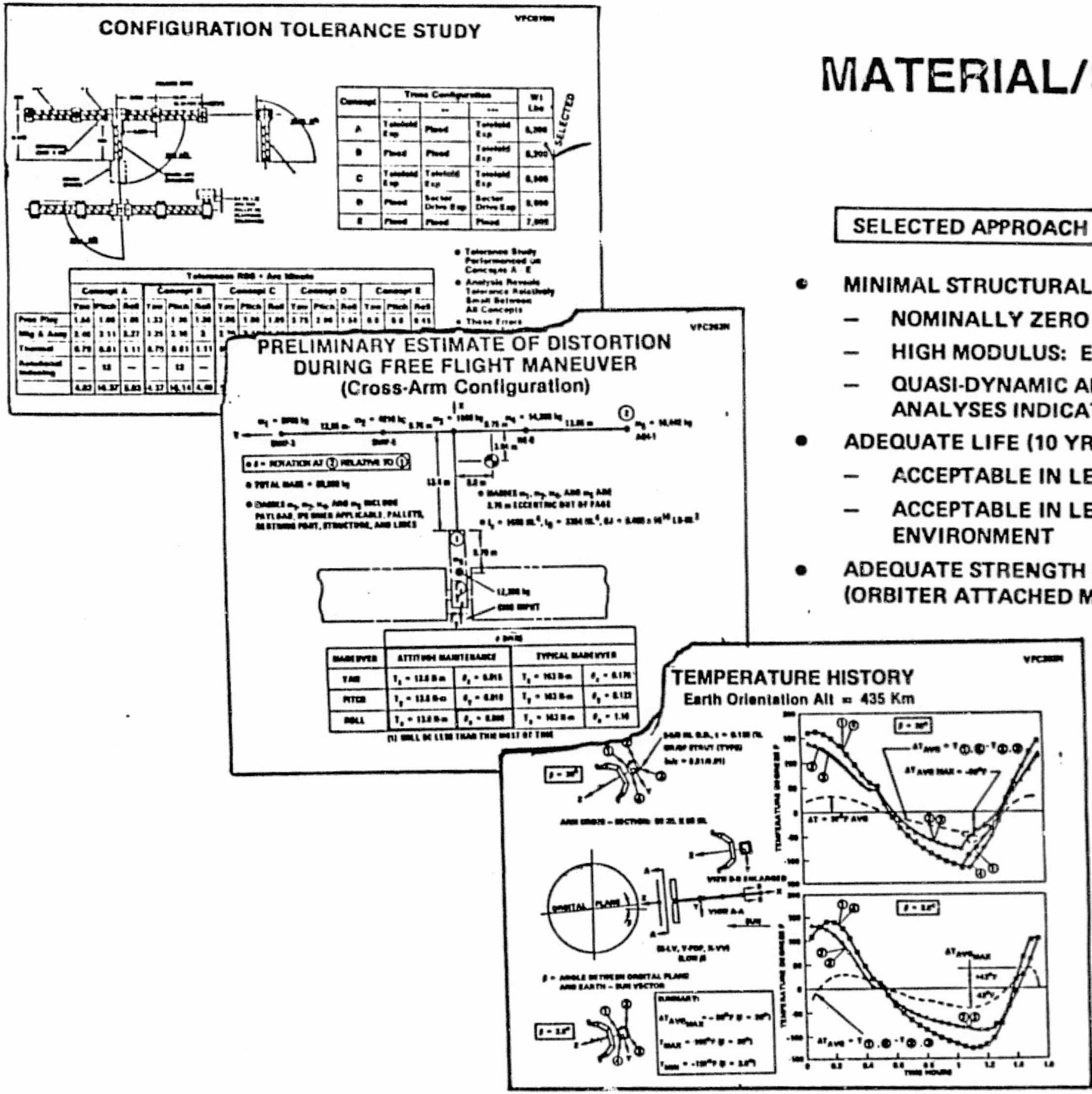
The quasi-dynamic analysis, while approximate, gives a preliminary estimate of the platform distortion during maneuver. The results show that the maximum distortion occurs for the roll condition and during attitude maintenance should be approximately a maximum of .1 arc min.

Temperature History (Earth Orientation) - The predicted structural orbital temperature history for the SASP graphite/epoxy trail arm longerons is shown on this figure. The predictions are based upon an earth orientation (Z-LV, Y-POP, X-VV) for β angles of 2.5° and 30°.

For the β = 2.5° solution, the temperature excursion of longerons (1) and (4) ranges from T_{max}=142°F to T_{min}=-127°F. The ΔT between longerons (1), (4) and (2), (3) varies to maximum extremes of ±43°F.

For the β = 30° solution, the temperature excursion of longerons (1) and (4) ranges from T_{max}=163°F to T_{min}=-115°F. The ΔT between longerons (1), (4) and (2), (3) varies from a maximum positive value of 37°F to an average maximum negative value of -50°F.

These data are considered to be representative of the structural temperatures for low β angles with the exception of the range β < 2.5°. As β approaches zero, longerons (2), (3) shadow longerons (1), (4) with full shadowing occurring at β=0°. For this case the longeron to longeron ΔT's will be somewhat greater than shown.



MATERIAL/STRUCTURAL ANALYSIS

(CONT.)

SELECTED APPROACH

- MINIMAL STRUCTURAL DISTORTION
  - NOMINALLY ZERO CTE POSSIBLE
  - HIGH MODULUS: $E \sim 20 \times 10^6$ PSI
  - QUASI-DYNAMIC AND THERMAL DISTORTION ANALYSES INDICATE ATTRACTIVELY SMALL DISTORTIONS
- ADEQUATE LIFE (10 YR)
  - ACCEPTABLE IN LEO RADIATION ENVIRONMENT
  - ACCEPTABLE IN LEO THERMAL CYCLING ENVIRONMENT
- ADEQUATE STRENGTH FOR CRITICAL LOAD (ORBITER ATTACHED MODE)

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THERMAL DEFORMATION DYNAMICS

The current SASP structure is a graphite/epoxy with a low coefficient of thermal expansion (CTE). Some thermal deformation does occur and an analysis of the acceleration levels associated with the thermal deformation time histories was performed.

The graph shown defines the differential temperature (ΔT) across the SASP arm for on-orbit. Assuming the thermal deformation to be proportional to ΔT, the deflection and rotation of the end of an arm is shown. The conditions are noted to the right of the graph. The transitions from orbit-day to orbit-night and the opposite generate the fastest changing thermal characteristics with the most potential to disturb payloads. Transition from orbit-day-to-night is the worst case since the SASP radiated power-input power differential is maximum.

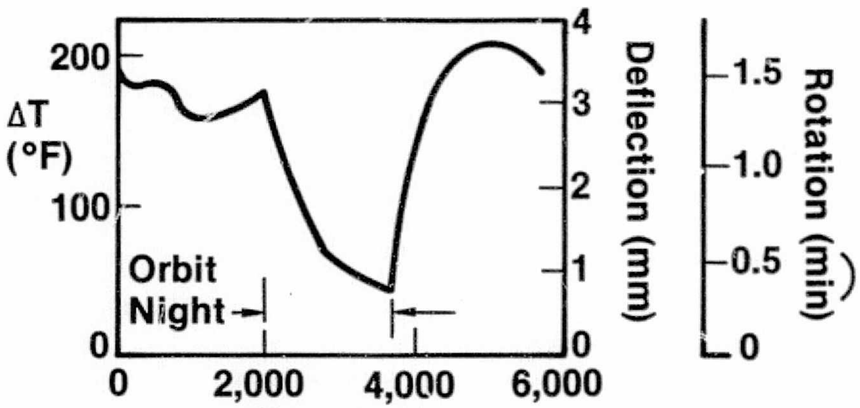
The mechanical dynamics were modeled as a resonance representing the first bending mode. Higher frequency modes will be excited by the thermal transient but first mode should dominate since the thermal deformation "shape" is similar to the mode shape of the first bending mode. The simplified dynamic model described on previous charts was used to define the first mode bending frequency (0.55 Hz).

The thermal transient at the orbit day-night transition was modeled as a linear system operating about the midpoint temperature of the transient. This temperature transient was input as a force through a gain factor to the resonance and the resulting acceleration peak determined. The gain factor is the ratio of static thermal deformation per degree of temperature differential (ΔT) times the effective spring constant of the first bending mode. The transition orbit-day to orbit-night takes about 7.8 sec which is short compared to the thermal time constant (1200 sec) but long compared to the first bending mode period (1.8 sec). Therefore, the input power was modeled as a step and a ramp for 7.8 sec to see the effect on the resulting acceleration (the ramp showed a factor of 6 less acceleration).

The results of the analysis indicate accelerations at the outer end of a SASP of well under 10^{-6} g's at the 0.55 Hz first mode bending frequency. Based on the previously described AGS pointing system model, the resulting payload line-of-sight disturbances are below the 0.01 arc-sec noise level of the Annular Suspension Pointing System. Therefore, it is preliminarily concluded that thermal deformation transients are not significant to either low-g payloads or pointing payloads.

THERMAL DEFORMATION DYNAMICS

SASP Strut Differential
Temperature Effects Example



Thermo Generated G-Levels

- Transition From Orbit-Day to Orbit-Night
- First Bending Mode Excitation Results in Maximum of 10^{-6} G's at 0.5 Hz
- AGS Pointing System Pointing Disturbance Less Than 0.01 sec Due to Thermal Distortion

- Rotation and Deflection at Outer End of SASP Cross Arm
- 435-km Altitude
- β Angle of 52°
- Graphite/Epoxy Struts
- Pallet/SASP Tilted 40° to Sun Line

- Auxiliary Pointing Systems Can Isolate Payloads from Thermal Deformations
- Materials Processing Experiments Are Not Impacted by Thermal Deformation Transients

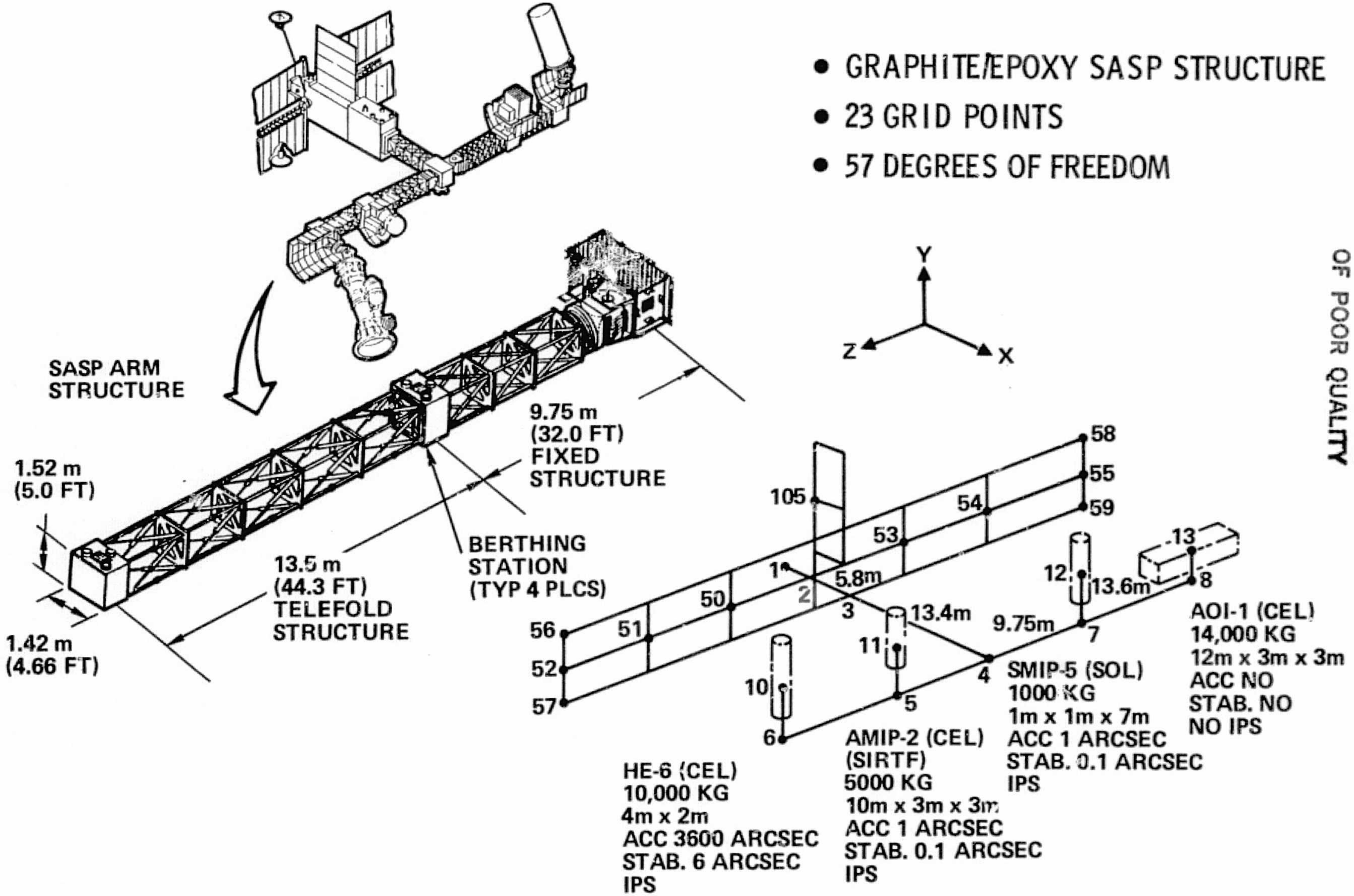
NASTRAN MODEL OF SASP/25 KW POWER SYSTEM

This figure shows the NASTRAN structural model developed for the SASP 2nd order extended configuration. The arm properties are based upon the truss module IB-B configuration. One solar and three celestial viewing payloads were selected as a representative mix of experiment mass and pointing requirements. Pallet and structural mass properties were input at modes 4, 5, 6, 7, and 8 while experiment mass properties were input at 10, 11, 12, and 13. Power Module mass was input at mode 2 and radiator mass at mode 105. Standoff and crossarm element lengths are noted.

This model contains 57 degrees of freedom and consists of 23 grid points. The mode shapes and frequencies have been calculated and a set of disturbance studies are now in progress. Frequency response characteristics and transfer characteristics will be calculated as a function of model damping factor. These data will be useful in determining shaped torque functions for the subsequent transient response analysis as well as isolation studies and controls analyses. The results of the frequency response and transient response analyses will be reported in the fourth quarter of the study.

NASTRAN MODEL OF SASP/25 KW POWER SYSTEM

- GRAPHITE/EPOXY SASP STRUCTURE
- 23 GRID POINTS
- 57 DEGREES OF FREEDOM



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MODE SHAPES, GROUPING, AND DENSITY

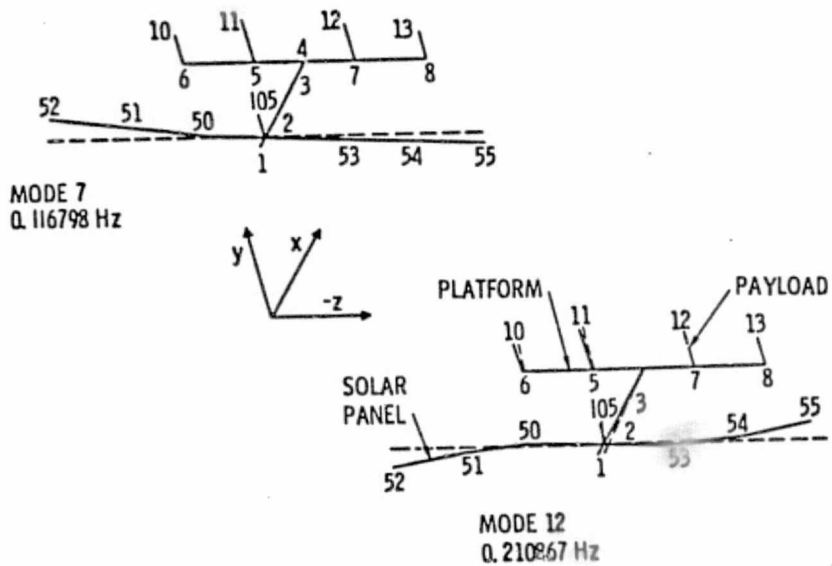
The outputs of frequency response analysis are:

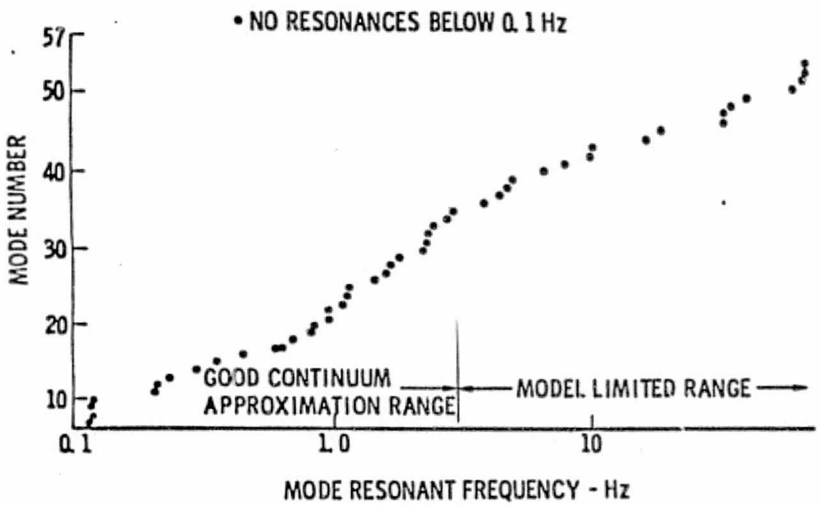
- Driving Point and Transfer Impedances Versus Structural Damping
- Pole and Zero Estimates
- Transient Response Forcing Function Selection
- Controls Analysis

The results indicate there were 22 modes below 1 Hz and that the model is useful to 3 Hz.

Modal Density - The plot of mode number vs. frequency provides an indication of the grouping and density of resonances. The slope of this plot indicates the frequency range over which the finite number of degrees of freedom in the model provide a reasonable approximation to the "real world". The reality of the model begins to break down where the slope of the plot begins to decrease. This effect is due, of course, to the finite number of parts used to represent a continuous structure. These higher order modes must still be carried in any solution with substantial damping in order to achieve proper convergence (mathematically).

MODE SHAPES, GROUPING AND DENSITY





- **Minimal Structural Frequency of 0.1 Hz Is Verified**
- **At Mode 12, Platform Movement Without Damping Becomes Significant**
- **Response Amplitude to a 34 Newton Meter Input is ±2.3 cm (±0.23 mm Possible With Increased Damping**
- **Model Limitation Due to Finite Number of Parts in Representation of Continuous Structure**
- **Solar Array Mast Modes Included but not Blanket Modes**

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MODAL DAMPING WITH VISCOELASTIC JOINTS

It is anticipated that the frequency response and transient analyses to be performed will show considerable benefit associated with reasonably high levels of structural damping. A convenient method of implementing enhanced damping in a truss structure such as the SASP is shown on the facing page. As can be seen, substantial loss factors can be achieved by providing a minimal amount of viscoelastic material at truss member joints without great sacrifice in stiffness. This concept, if applied to the SASP, could produce great increase in structural damping at virtually zero weight impact.

W.R.T. Phase - Damping reduces the rate of change of phase with frequency, thus simplifying filter design in control systems.

W.R.T. Amplitude - Damping reduces the response of the structure (per unit force) thus increasing allowable disturbance forces or allowing higher control system gains.

The ETA of 0.001 is considered achievable in a precision structure without any intentional damping. The ETA of 0.1 is achievable with 10% or less stiffness loss.

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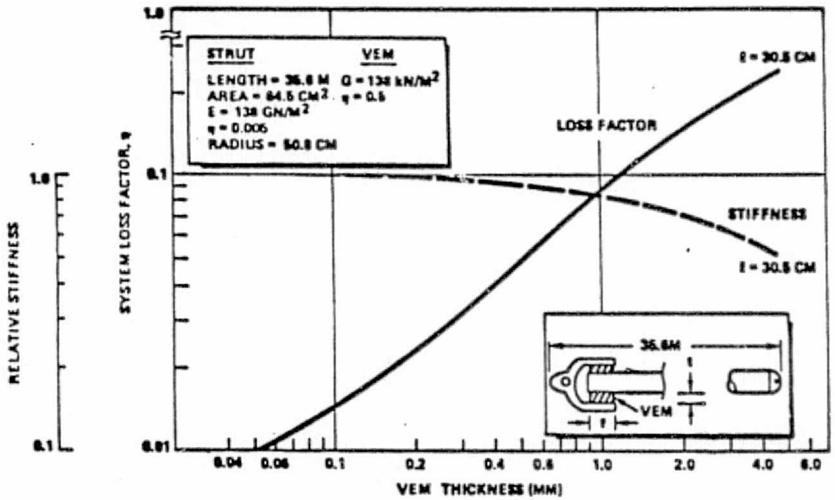
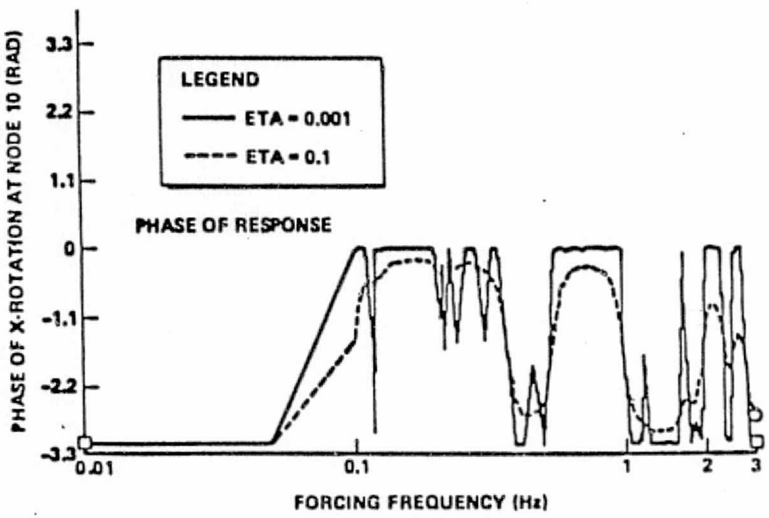
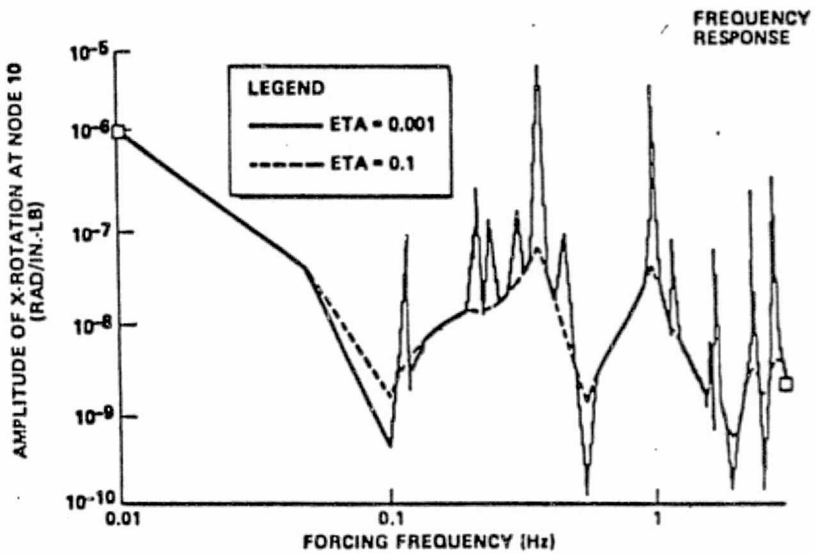
MODAL DAMPING WITH VISCOLASTIC JOINTS



- Considerable Damping Is Possible With Little Loss of Stiffness (MDAC Study for USAF)
- Reasonably Achievable Damping Coefficients Improve Platform Response Considerably (Unit Torque on Node 10) and Simplify Control Filter

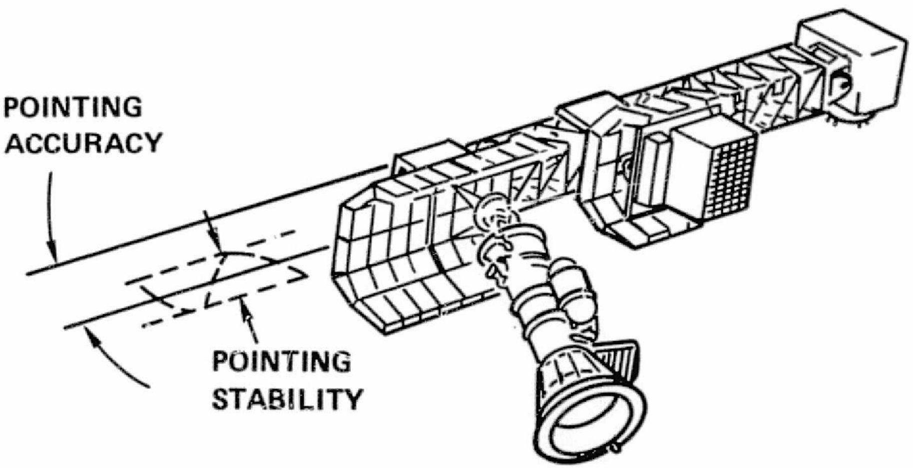




DYNAMICS

ISSUES

- EXTERNAL DISTURBANCES
- STRUCTURAL REQUIREMENTS
- AUXILIARY POINTING SYSTEM PERFORMANCE
- IMPACT OF PAYLOAD DISTURBANCES



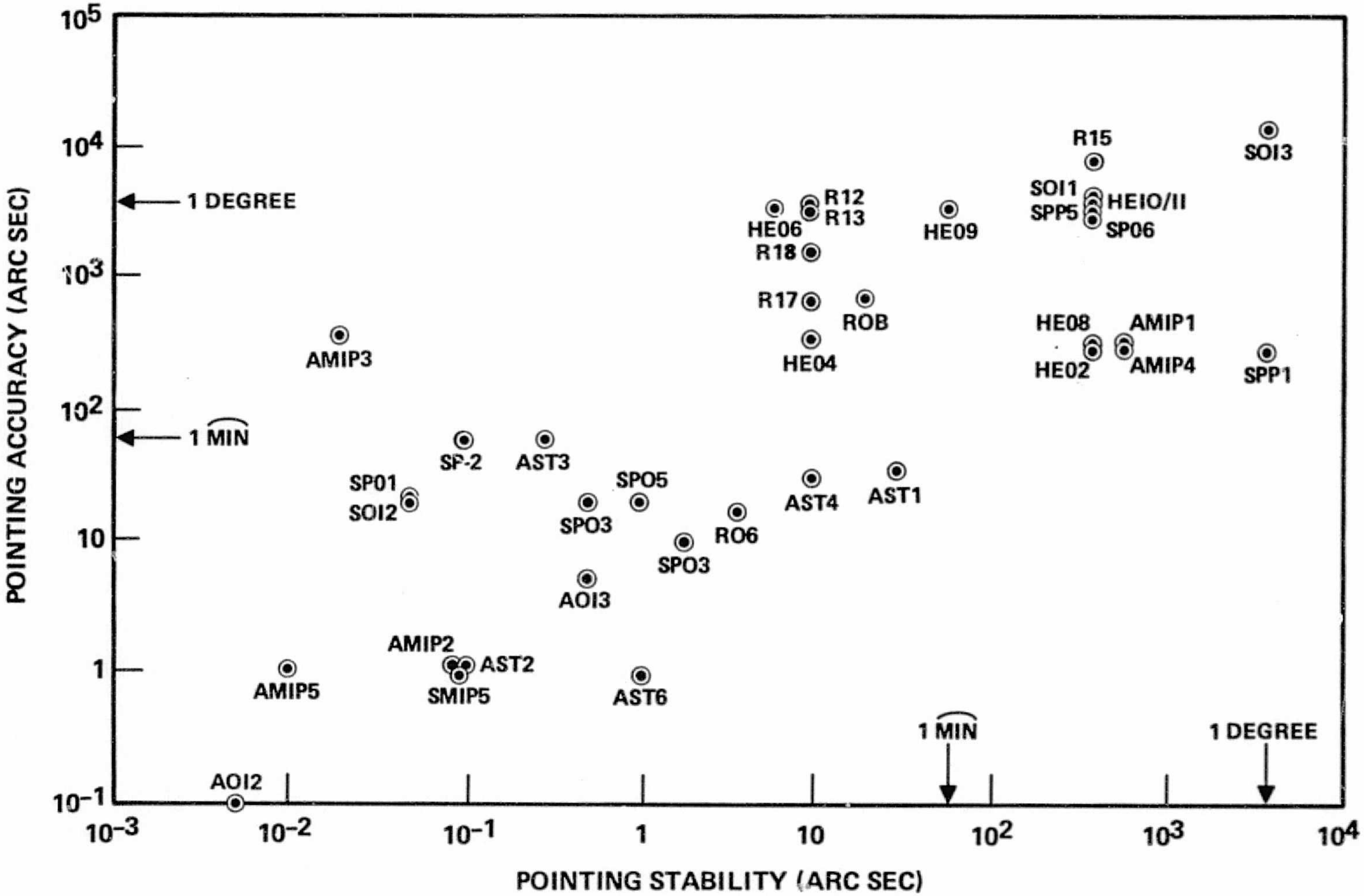
ANALYSES

- DEFINED DISTURBANCES
- BENDING MODES DEFINED
  - PRELIMINARY
  - NASTRAN
- THERMAL TRANSIENTS
- DEFINED PALLET DYNAMIC ENVIRONMENT
- DEFINED ISOLATION EFFECTIVENESS OF APS
- INVESTIGATED HIGH FREQUENCY STRUCTURES
- DETERMINED MANUFACTURING TOLERANCES
- INVESTIGATED IMPACT OF PASSIVE STRUCTURAL DAMPING
- INVESTIGATED TORQUE SHAPING

CONCLUSIONS/RECOMMENDATIONS

- ARM STRUCTURE $f_n > 0.1$ Hz
- PLATFORM ENVIRONMENT MORE BENIGN THAN SPACELAB
- EXPERIMENT POINTING SYSTEMS EXPECTED TO PERFORM BETTER ON PLATFORM
- EPS PLUS IMC OR MAGNETIC SUSPENSION SHOULD SATISFY MOST POINTING REQT'S
- SASP POINTING W/O EPS
  ACCURACY $<$ 20 $\widehat{\text{MIN}}$
  STABILITY $<$ 10 $\widehat{\text{MIN}}$

EXPERIMENT POINTING REQUIREMENTS

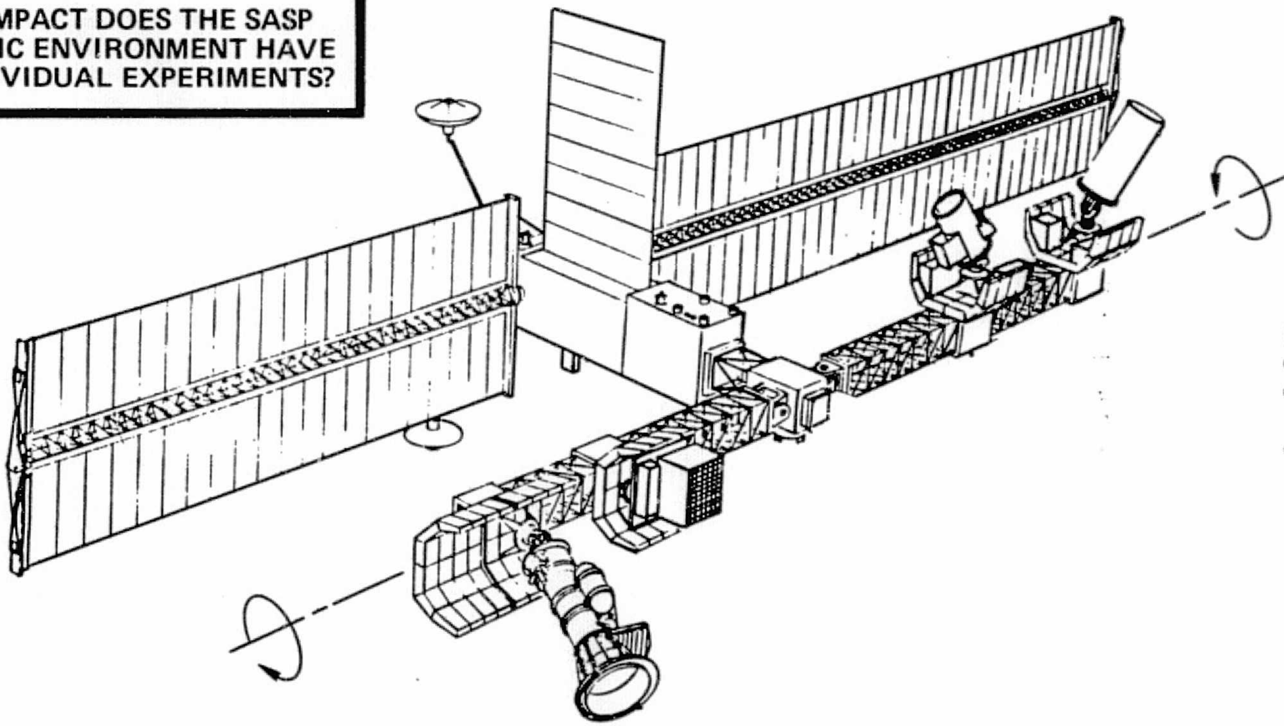


SASP DYNAMIC ENVIRONMENT

Disturbances which the induced dynamic motion of the PS, Platform, and payloads are noted along with its sources. High frequency disturbances due to rotating machinery such as CMG's and fluid pumps are expected to be small amplitude but may be significant to payloads with very tight pointing stability requirements. Thermal distortions can occur relatively quickly (5 minutes) on truss structures when changing from sun to shadow. Payload slewing can cause whole system rotations of 0.1 to 0.2 degrees. Extreme disturbances such as large PS/Platform maneuvers, orbit-keeping operations, or Orbiter docking will likely require suspension of experiment operations.

SASP DYNAMIC ENVIRONMENT

WHAT IMPACT DOES THE SASP DYNAMIC ENVIRONMENT HAVE ON INDIVIDUAL EXPERIMENTS?



EXPERIMENTS
- SLEWING
- ROTATING MECHANISMS
- VENTING

EXTERNAL
- GRAVITY-GRADIENT TORQUES
- AERODYNAMIC MOMENTS
- DOCKING
- ORBITER OPERATIONS
  - THRUSTERS
  - CREW

POWER SYSTEM
- SOLAR-PANEL ROTATIONS
- ANTENNA MOVEMENT
- ATTITUDE MANEUVERS
- CMG'S
- ORBIT-KEEPING ACCELERATION
- THERMAL DISTORTION
- FLUID PUMPS

PLATFORM
- ROTATING JOINT
- ARM ROTATION AT FOUR DEG PER MIN
- FLUID PUMPS
- THERMAL DISTORTION

DISTURBANCE ACCELERATIONS FOR FIRST ORDER PLATFORM

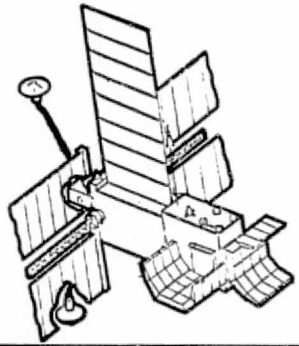
The rigid body linear accelerations at the outer ends of rear and side pallets for a Sortie-Combo and a Free-Flyer configuration are shown for several disturbance sources. The aero-drag variation is due to diurnal bulge atmospheric density variations and the orbital variation of the projected area perpendicular to the velocity vector. A solar activity of 150 X 10^{-22} watt^2/sec (nominal 1991 solar maximum) and an altitude of 435 km was assumed.

The orbital mechanics and maneuver g-levels are higher for the Sortie-Combo configuration because the distance from the c.g. is greater.

Payload slewing and CMG disturbances vary because the moments-of-inertia vary from axis to axis. The 34 NM ASPS disturbance torque corresponds to the maximum gimbal moment capability for APS's* being considered. Note that for the Free-Flyer configuration the 34 NM disturbance results in g-levels in excess of the 10^{-5} g materials processing requirement so that some payload slew acceleration limitations will be imposed. The CMG torques correspond to Skylab data. The typical value is an estimate based on the fact that Skylab operated with a torque limit of 55 N-M (1 deg/sec gimbal rate limit) during most of the later flight. It was assumed that short term oscillations required 25 percent of the limit. Momentum management maneuvers (occurring several times per orbit) reached the 55 NM limit, however. Therefore, the PS attitude control and momentum management schemes used during low-g operations will probably have to be specially designed for the low-g mode to achieve the 10^{-5} g requirement.

The Orbiter disturbances are unacceptable from a materials processing viewpoint. The small Orbiter thrusters (VRCS) result in well over the 10^{-5} g requirement. Even minimum crew disturbance levels appear to exceed the 10^{-5} g requirement.

*Auxiliary Pointing Systems



DISTURBANCE ACCELERATIONS FOR FIRST-ORDER PLATFORM

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DISTURBANCE SOURCE	ACCELERATION (10^{-6} G'S) SORTIE COMBO REAR PALLET	SORTIE COMBO SIDE PALLET	FREE-FLYER REAR PALLET	FREE-FLYER SIDE PALLET
AERO DRAG				
X-POP, Y-PSL	0.04 – 0.2	0.04 – 0.2	0.1 – 0.9	0.1 – 0.9
Z-LV, Y-POP	0.02 – 0.2	0.02 – 0.2	0.05 – 0.8	0.05 – 0.8
ORBITAL MECHANICS				
X-POP, Y-PSL	1.6	1.8	0.87	0.66
Z-LV, Y-POP	1.9	1.9	0.38	0.56
0.1 DEC/SEC MANEUVER WORST DIRECTION	2.5	3.5	2.0	1.4
PAYLOAD SLEWING (RIGID BODY) ASPS MAX (34 N-M)	1.7 – 6.1	2.6 – 7.3	4.1 – 46	14 – 25
CMG TORQUES				
MINIMUM (0.33 N-M)	0.017 – 0.061	0.026 – 0.073	0.041 – 0.46	0.14 – 0.25
TYPICAL (14 N-M)	0.72 – 2.6	1.1 – 3.1	1.7 – 20	5.9 – 11
CREW DISTURBANCE (8–215N, PITCA)	14 – 360*	16 – 420*	110 – 3000**	81 – 2200**
ORBITER VRCS (2 THRUSTERS) PITCH UP	290	350	–	

NOTE: MATERIALS PROCESSING REQUIREMENT IS 10^{-5} G's

*INPUT IN LOWER CABIN

**INPUT ON AFT END OF AFT PALLET

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PAYLOAD DISTURBANCES

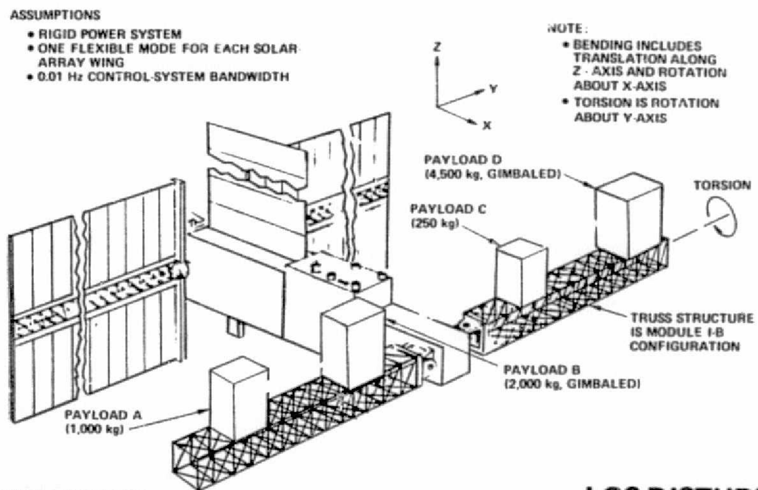
The largest disturbance identified excluding Orbiter and PS thrustor operations is the slewing of a payload instrument at the maximum ASPS gimbal moment of 34 N-M. This chart shows a representative configuration that was modeled to evaluate the impact of this disturbance input at payload D. Results of the analysis for uncompensated response are presented in Figure 2-27. The MODE column defines the character of the mode shape with respect to where most of the motion occurs. For example, the RIGID BODY mode corresponds to a closed-loop control system mode and neither the solar array or Platform are bending significantly. The A through D columns define the rotation of the corresponding payload (A and C) or base of the auxiliary pointing system of the payload is used (B and D). The results indicate significant rigid body motion occurs (0.16 deg) which is characteristic of the 0.01 Hz controller bandwidth with no damping. Other rotations appear small with the exception of the second torsion mode which could be significant to some payloads with tight stability requirements.

The addition of an auxiliary pointing system significantly reduces the payload disturbances. A representative value for ℓ is three meters; the values in the first column for each payload can be multiplied by three to obtain realistic LOS errors.

Most of the disturbances are in the "noise level". Some exceptions exist, however. The LOS error for payload C and second torsion mode is 0.15 arc-sec (assuming ℓ = three meters). Also, the fourth torsion mode and fifth bending mode result in LOS errors which are above the AGS "noise". (The accuracy of these higher frequency modes is questionable because of the simplified flexible dynamic model used.)

The results shown here indicate that the interpayload slewing disturbances will be acceptable to most pointing payloads. A few payloads with the most severe performance requirements may impose some slewing restrictions on other payloads. Internal instrument motion compensation systems may be required to compensate for other payload slewing disturbances.

PAYLOAD DISTURBANCES



UNCOMPENSATED RESPONSE

MODE	FREQ (Hz)	ROTATION** (SEC) AT INDICATED PAYLOAD A	B	C	D
RIGID BODY	0.01	586	586	586	586
1ST SOLAR ARRAY	0.054	0.001	0.001	0.002	0.002
2ND SOLAR ARRAY	0.055	1.6	1.5	1.6	1.6
1ST BENDING	0.55	0.82	0.71	0.48	0.67
2ND BENDING	0.94	~0	~0	~0	~0
3RD BENDING	1.4	~0	~0	~0	~0
4TH BENDING	1.9	0.24	0.08	0.02	0.10
5TH BENDING	2.9	0.13	0.006	0.02	0.25
1ST TORSION	0.63	0.42	0.28	0.004	0.005
2ND TORSION	0.86	0.14	0.05	19	29
3RD TORSION	2.14	0.02	0.05	~0	~0
4TH TORSION	2.16	0.02	0.04	2.4	2.2

*MAXIMUM ANNULAR SUSPENSION POINTING SYSTEM (ASPS) GIMBAL MOMENT

**AUXILIARY POINTING SYSTEMS REDUCE ROTATIONS FOR EXPERIMENTS (COMPENSATED RESPONSE)

LOS DISTURBANCES USING AGS

MODE	FREQ (Hz)	PAYLOAD A ''LOS$_Y$/Δ (ARC SEC/m)	PAYLOAD A ''LOS$_Z$ (ARC SEC)	PAYLOAD B ''LOS$_Y$/Δ (ARC SEC/m)	PAYLOAD B ''LOS$_Z$ (ARC SEC)	PAYLOAD C ''LOS$_Y$/Δ (ARC SEC/m)	PAYLOAD C ''LOS$_Z$ (ARC SEC)
RIGID BODY	0.01	1×10^{-5}	3×10^{-4}	1×10^{-5}	2×10^{-4}	1×10^{-5}	1×10^{-4}
1ST SOLAR ARRAY	0.054	~0	2×10^{-6}	~0	2×10^{-6}	~0	2×10^{-6}
2ND SOLAR ARRAY	0.055	6×10^{-6}	1×10^{-4}	6×10^{-6}	1×10^{-4}	6×10^{-6}	5×10^{-5}
1ST BENDING	0.55	1×10^{-3}	0.012	9×10^{-4}	3×10^{-3}	6×10^{-4}	2×10^{-3}
2ND BENDING	0.94	~0	7×10^{-7}	~0	1×10^{-6}	~0	3×10^{-6}
3RD BENDING	1.4	~0	3×10^{-6}	~0	2×10^{-6}	~0	1×10^{-6}
4TH BENDING	1.9	2×10^{-3}	7×10^{-3}	6×10^{-4}	7×10^{-3}	1×10^{-4}	5×10^{-3}
5TH BENDING	2.9	2×10^{-3}	4×10^{-3}	8×10^{-5}	7×10^{-3}	3×10^{-4}	$\boxed{0.020}$
1ST TORSION	0.63	7×10^{-4}	–	5×10^{-4}	–	6×10^{-6}	–
2ND TORSION	0.86	4×10^{-4}	–	1×10^{-4}	–	$\boxed{0.049}$	–
3RD TORSION	2.14	2×10^{-4}	–	4×10^{-4}	–	~0	–
4TH TORSION	2.16	2×10^{-4}	–	4×10^{-4}	–	$\boxed{0.021}$	–

*ANNULAR SUSPENSION POINTING SYSTEM GIMBAL SYSTEM
**MAXIMUM AGS TORQUING CAPABILITY
NOTES: SIRTF PAYLOAD WITH FIVE PERCENT MASS PROPERTIES PREDICTION ERROR ASSUMED

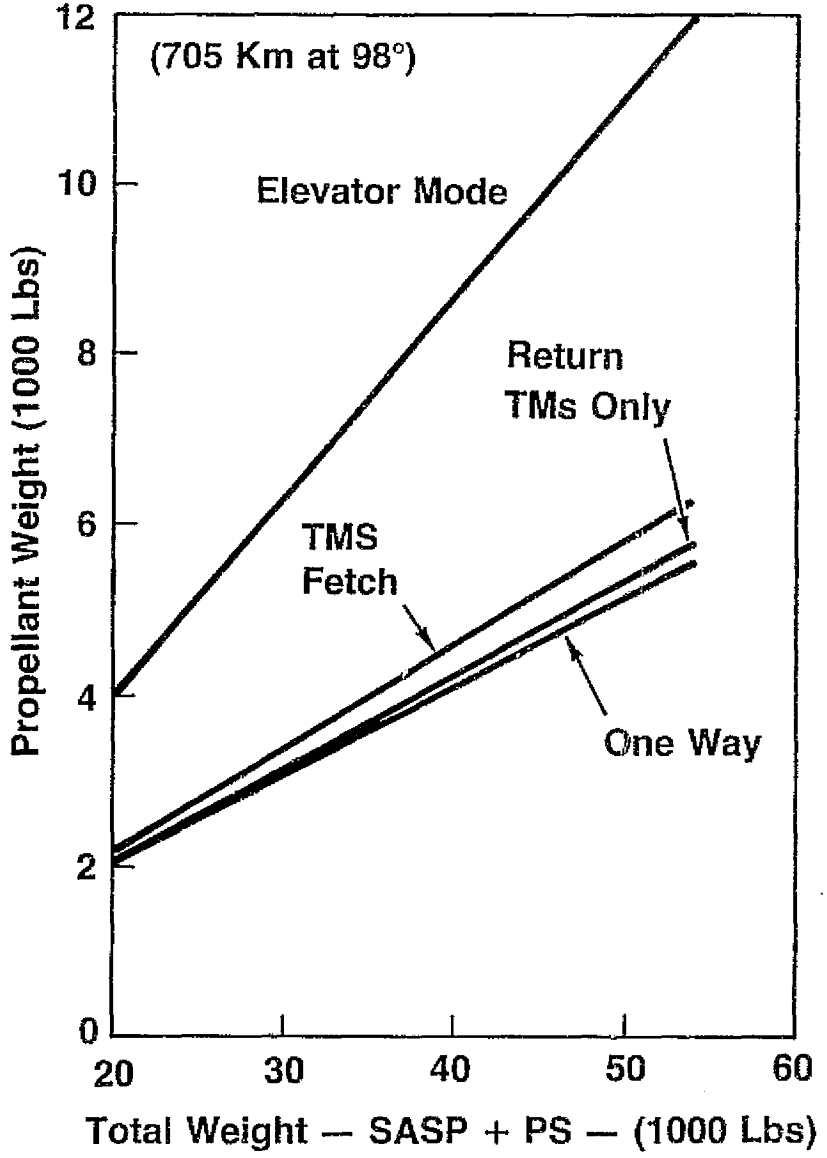
COST OF ORBIT CHANGES

Two special orbits were identified in the companion TRW requirements study. The first, a 705 km altitude, 98° inclination sun synchronous orbit, satisfies many earth viewing experiment requirements. The second, a 200 km by 2000 km elliptical orbit might partially satisfy experiments with either very high or very low altitude requirements. For both of these orbits the key issue is how to achieve the orbit.

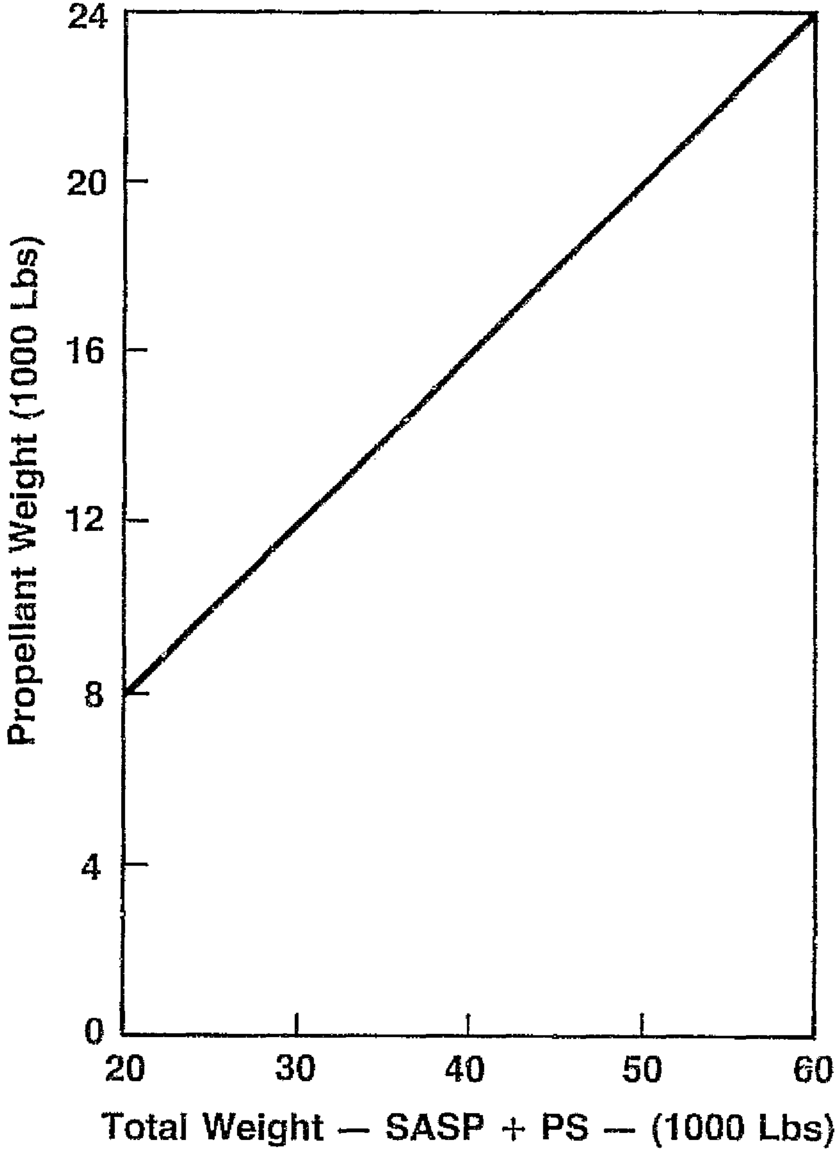
In the figure the propellant requirements for achieving the sun-synchronous are shown as a function of platform weight. Several modes are considered: (1) a one-way mission where the Platform and propulsion unit are treated as expendable payload, (2) the Platform is kept in its high altitude orbit and a TMS employed to ferry payloads up and down, and (3) an elevator mission where the propulsion system stays with the Platform ferrying the Platform between an Orbiter rendezvous compatible altitude and the 705 km operational altitude.

Propellant required to achieve the 200 by 2000 km elliptical orbit is presented in the same format. These data are conservative assuming the propellant cost in terms of impulsive velocity to reacquire the initial 435 km orbit to be equal to that of injection into the elliptic orbit. High perigee drag levels should significantly reduce apogee altitude, therefore, reducing propellant requirements for returning to the nominal orbit.

DELIVERY COST TO SUN SYNCHRONOUS ORBIT



COST OF ESTABLISHING THEN LEAVING A 200 X 2000 Km ORBIT



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COMMUNICATIONS/DATA AND POWER

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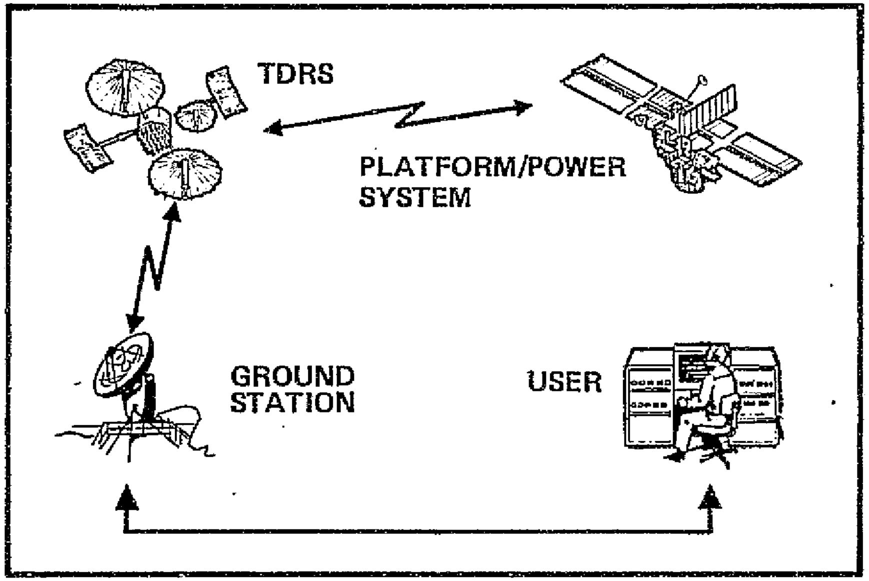
COMMUNICATIONS AND DATA MANAGEMENT

This overview chart describes the requirements envelope for SASP communication and data management, the challenges, and optional approaches associated with meeting the requirements, and the key features of the selected approach. Requirements include high peak rate data handling, real-time data and uplink command handling for payload interactive control, NASA data system compatibility, and Orbiter interface accommodations. Optional approaches considered are primarily concerned with the allocation of control and data handling functions among the Power System, the Platform, and the payload carrier (pallet). The selected approach allocates detailed experiment control and data formatting to the pallet while retaining payload "executive" level control in the Power System computers. Payload data storage and multiplexing are provided on the Power System and the Platform to provide a capability buildup that accommodates increasing payload data loads.

COMMUNICATIONS AND DATA MANAGEMENT



REQUIREMENTS ENVELOPE

- EXP DATA RATES $\leqslant$ 120 MBPS PER PAYLOAD
- NEAR-REAL-TIME DATA (50-200 Kbps) FOR INTERACTIVE CONTROL
- PROVIDE PAYLOAD COMMAND HANDLING
- TDRSS, POWER SYSTEM, AND NASCOM COMPATIBILITY
- PROVIDE C&W AND SASP INTERFACE FOR ORBITER

OPTIONAL APPROACHES

- CENTRALIZED VS DISTRIBUTED EXP CONTROL AND DATA FORMATTING
- MULTIPLEXING PAYLOAD DATA ON SASP VS POWER SYSTEM
- PAYLOAD DATA STORAGE ON PS, PLATFORM, OR PAYLOAD CARRIER (PALLET)

SELECTED APPROACH

- DETAILED EXP CONTROL, DATA EDITING, DATA FORMATTING FUNCTIONS ALLOCATED TO PAYLOAD
- PAYLOAD ON-OFF CONTROL, P/L DATA MULTIPLEXING CENTRALIZED
- HIGH RATE DATA RECORDERS ARE NECESSARY TO PRECLUDE DATA LOSS DUE TO TDRSS UNAVAILABILITY
- SASP OFFERS ADVANTAGES OVER FREE FLYERS IN EFFICIENT UTILIZATION OF TDRSS
- POWER SYSTEM SUPPORTS FIRST ORDER PLATFORM/CONVERTED SPACELAB PAYLOADS; SECOND ORDER PLATFORM SUPPORTS LATER HIGHER DATA PAYLOADS

FOLLOW-ON ACTIVITY

- END-TO-END DATA FLOW STUDY

PAYLOAD DATA REQUIREMENTS ENVELOPE

The payload characteristics provided by NASA have been examined and a set of "typical" characteristics describing the payload data interface are shown. The curve shows the distribution of peak data rates per payload for 62 payloads in the SASP data base. Ninety-three percent of the payloads have peak data rates of 10 Mbps or less. Data acquisition duty cycles are not defined for many payloads but an estimate of 4 MHz for the upper limit average data rate was made based on the few payloads with defined duty cycles. Slow-scan TV requirements are typical with a few requirements for a full 4.5 MHz video signal. A large percent of payloads want some housekeeping data ($\leq$ 50 Kbps) in near real-time for purposes of interactive control along with a capability to send uplink commands and data at a rate in the 1 to 2 Kbps range. The most stringent time reference accuracy defined to date is 10^{-5} seconds.

PAYLOAD DATA REQUIREMENTS ENVELOPE

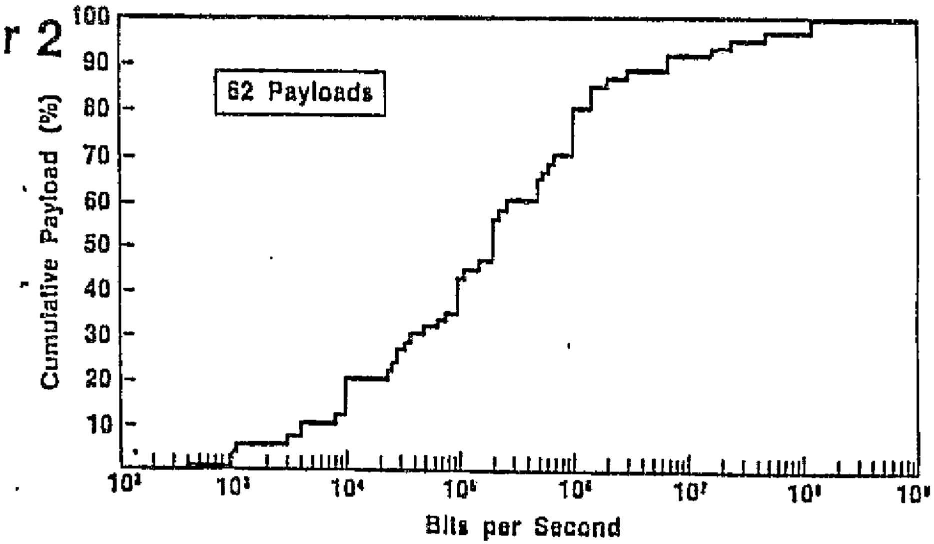
Digital Data Rate: $\leqslant$10 MBPS Peak (93% Payloads)

Video/Analog Data: < 500 kHz Analog
1 or 2 Channels Slow-Scan TV
Fast-Scan TV — Some Payloads

Acceptable Data Delay: Some Data ($\leqslant$50 KBPS) Real Time for Interactive Control — Delays of 1 Orbit to Several Hours OK for Bulk of Data

Uplink Commands and Data: Low Rate (1 or 2 KBPS Peak)

Timing Reference Requirement: 10^{-5} sec Acc



DATA MANAGEMENT OPTIONS AND SELECTIONS

The key configuration options for the platform data management subsystem are shown. Allocation of the detail payload control functions to the pallet rather than the central subsystem provides a simpler platform/pallet interface and eases the on-orbit integration task. Prelaunch checkout at the pallet level is also enhanced and the payload data is more autonomous than with a more centralized system. Payload data storage should be centralized to insure efficient utilization of the communication channels and to minimize the high rate data handling that would be required with storage on the pallet. Similarly, payload data multiplexing is handled in the central data subsystem. An option exists on the allocation of centralized data storage and multiplexing to the Power System versus the Platform. Some amount of storage and multiplexing are required on the Power System to accommodate the first order platform payloads. It is suggested that the remaining storage and multiplexing capacity be placed in the Platform to defer costs.

DATA MANAGEMENT OPTIONS AND SELECTIONS

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Centralized vs $\boxed{\text{Distributed}}$ Payload Control

- On-Orbit Integration
- Prelaunch Checkout Autonomy
- Payload Data Autonomy
- Overall Data Processing Efficiency

Multiplexing on $\boxed{\text{Power System}}$ vs. $\boxed{\text{Platform}}$

- Accommodation of First Order Platform
- Cost Deferral
- Compatibility with Data Storage Configuration

Payload Data Storage on $\boxed{\text{Power System}}$, $\boxed{\text{Platform,}}$ or Pallet

- Accommodation of First Order Platform Payloads
- Efficient Use of High-Rate TDRSS Channels
- Cost Deferral
- Minimize High Rate Data Handling

EXPERIMENT ON-BOARD PROCESSING

FUNCTION ALLOCATION EXAMPLE

This chart shows an example of how experiment-related data processing functions would be allocated to the platform central processor and to a dedicated experiment processor. The allocation criteria was (1) use the central processor for those functions that can only be done centrally and those functions that are critical to overall mission success, and (2) use the DEP for all other functions. In this example, the central processor manages the platform subsystems, relays commands and data from the ground to the payload, provides platform and environmental data to the payloads, and provides a payload macroscheduling service where this is necessary to assure overall mission success. All detailed management of the experiment is allocated to the dedicated processor.

EXPERIMENT ON-BOARD PROCESSING FUNCTION ALLOCATION EXAMPLE

Central Processor

- Manage common resources (eg power)
- Down load experiment programs
- Relay commands from ground
- Provide common platform data (e.g. attitude, position)
- Macroschedule experiment operations

Dedicated Experiment Processor

- Equipment checkout and calibration
- Experiment operation (microscheduling)
- Input data/command processing
- Data acquisition (formatting, annotation)
- Data processing (sorting, correlating, estimating)

APPROACH TO ON-ORBIT PAYLOAD/PLATFORM INTEGRATION

The goal of successful, efficient integration of payloads with the orbiting SASP must influence the SASP design from the start. A key to successful integration is to design the payloads to be as autonomous as they can reasonably be so that platform to payload interfaces can be kept simple. The autonomous payload will be less susceptible to mission failure caused by degraded SASP subsystem operation. Interfaces between the payload and the SASP will be standardized so that design and integration experience will be of increasing value to later payloads. SASP central processor software will be designed to be modular so that modules associated with changing payloads can be added or deleted without impact to remaining software functions. Payloads being readied for an already orbiting SASP will be integrated with a SASP simulator prior to launch. The simulator will simulate other payloads as well as SASP subsystems.

APPROACH TO ON-ORBIT PAYLOAD/ PLATFORM INTEGRATION

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- Payload Autonomy
  - Experiment
  - Pallet
- Standard Interfaces
  - Experiment
  - Pallet
- Software Modularity (Central Processor)
  - Housekeeping Data & Commands
- Prelaunch Integration with SASP Simulator
  - Hardware Simulator
  - Software Simulator

SASP EXPERIMENT INTEGRATION PROCESS

An integration process is shown defining the steps that are required to assure a successful on-orbit integration of a payload with a SASP, where the SASP may have been in orbit long before the payload began its checkout and integration. The first two steps in the process, experiment integration and payload integration, are identical in concept to current Spacelab payload integration activities. An integrated payload, including its carrier (pallet), is then integrated with a SASP simulator where physical and functional (including software) interfaces between the payload and the (simulated) SASP are verified. This stage would include a simulation of other payloads that would be on board SASP at the same time. (Real payloads would of course be used where available.) Payload/Orbiter integration generally would not involve payload operation since most payloads would not be active while in the Orbiter payload bay. Payload/platform on-orbit integration would be a carefully planned and rehearsed operation controlled by the Orbiter crew and the ground control personnel.

COMMAND/DATA FUNCTIONS IN SASP EXPERIMENT INTEGRATION PROCESS

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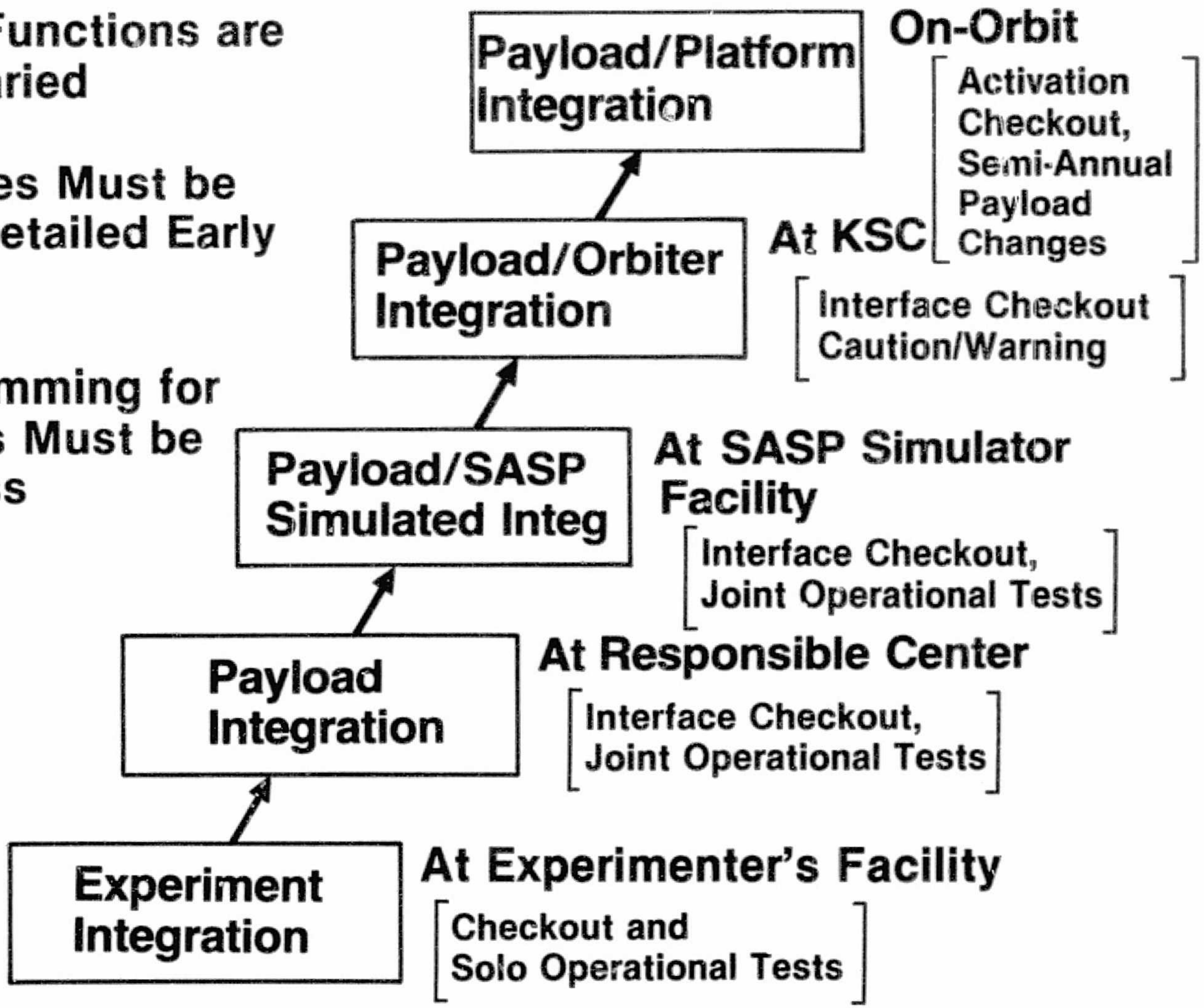
- Command/Data Functions are Extensive and Varied
- Multiple Interfaces Must be Coordinated in Detailed Early Plans
- Orbital Reprogramming for Payload Changes Must be Efficient/Faultless

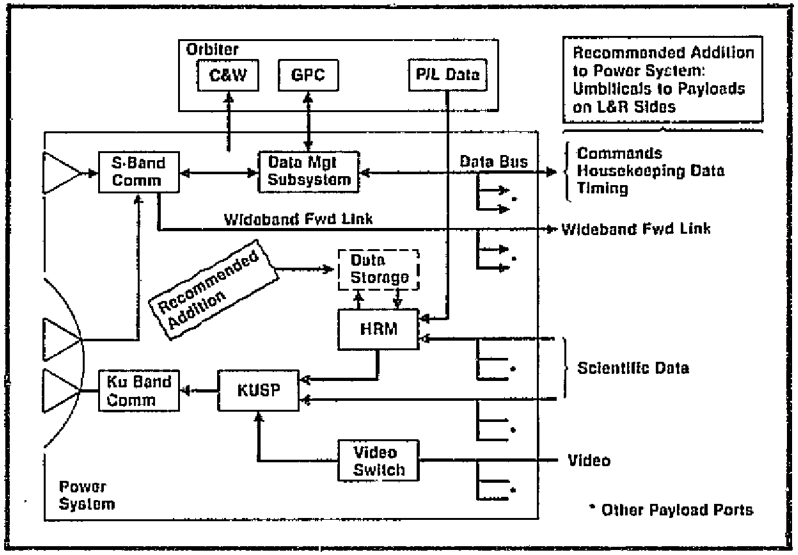


CDMS CONFIGURATION

The communications and data handling subsystem for the First Order Platform is essentially the Reference 25 kW Power System communication and data subsystem. It is recommended that payload data storage be added to provide a Spacelab-equivalent storage capability for early platform payloads. Other suggested Power System changes provide enhanced capabilities to accommodate second order platform payload groups. These suggested changes include a higher scientific data rate capability and higher continuous housekeeping data rate capability.

The growth from the First Order Platform to the Second Order Platform includes the expansion of the data subsystem to add storage and multiplexing for later, more prolific payloads. The Data Multiplexer and Switching Matrix can act as a multiplexer to merge two or more data streams onto a single recorder channel, can be a submultiplexer feeding the HRM in the Power System, and can route the various input streams of high rate data to the appropriate device (HRM, recorder, KuSP). The low rate data bus is carried through to the payload ports with Remote I/O units provided for platform subsystem control and data acquisition. The wideband forward link is carried through the Platform to the payload ports. Orbiter ports will provide a means for the Orbiter data processing system to access the payload data bus for data transfer and control. Power System/platform caution and warning parameters will be provided to the Orbiter.

CDMS CONFIGURATION



- Adds P/L Data Storage to Ref. PS Configuration
- Capabilities Equal to or Better Than Spacelab
- Comm Capabilities Allows for Higher Data Rate Payloads

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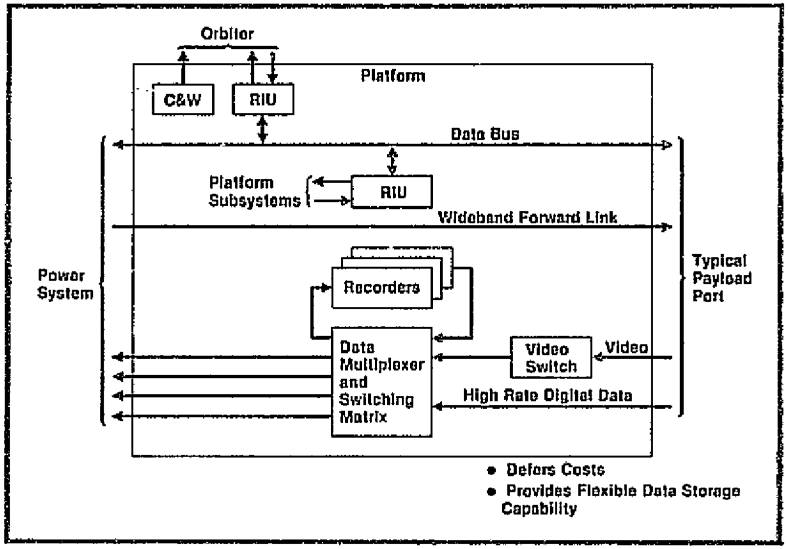
- Increased Multiplexing and Storage Capacity
- Data Processing for Payloads Allocated to Payload Equipment Except for Minimal Support by PS Data Processors



TYPICAL SASP EXPERIMENT END-TO-END COMMAND & DATA FLOW

The SASP/experiment data interface is very similar to the Spacelab/experiment interface. The scientific data interface with the HRM can be identical. The command, housekeeping data, and timing interfaces are different in detail because of the use of STACC hardware in the SASP. These detail differences can be accommodated by a new SPSME module such that the interface to the unique experiment hardware will not be affected.

TYPICAL SASP EXPERIMENT END-TO-END COMMAND AND DATA FLOW

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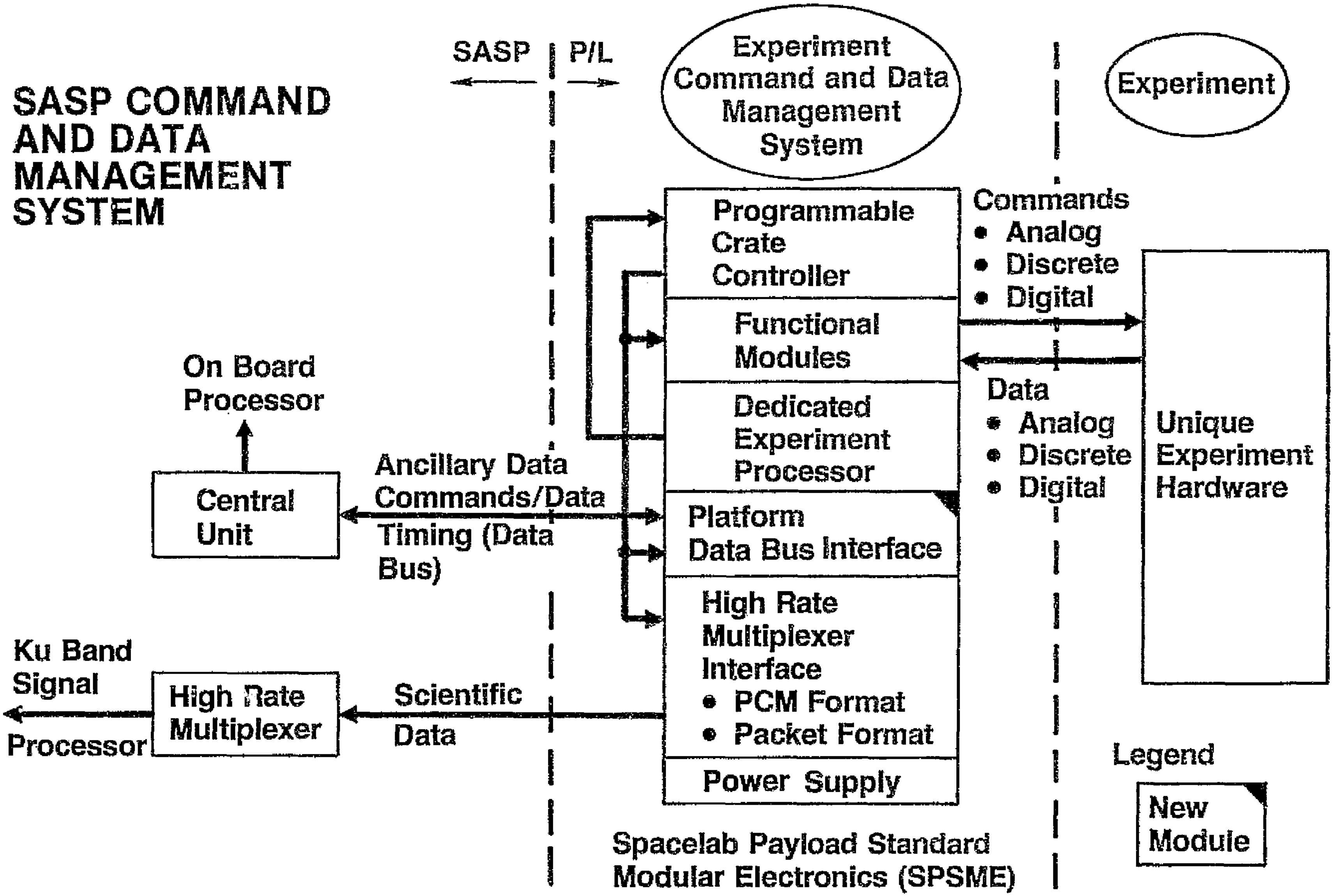

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TDRSS UTILIZATION OPTIONS

Several ways of using the TDRSS were compared as shown on the basis of forward and return link data rate capability and on the interactive control capability provided. It is assumed that payload interactive control capability requirements can be satisfied through a time-shared MA forward link. If this is not the case, a dedicated SA link may be required. However, as can be seen on the chart, a dedicated SA channel would be inefficiently used by SASP from a total bits per orbit viewpoint. Platform payload sets that require continuous data at rates that exceed the MA return channel capacity are a second case where a dedicated SA channel may be required.

TDRSS UTILIZATION OPTIONS

TDRSS OPTIONS	RETURN LINK: PEAK RATE	RETURN LINK: BITS/ORBIT	RETURN LINK: CONTINUOUS RATE	FORWARD LINK PEAK RATE	INTERACTIVE CONTROL CAPABILITY
SASP NEED	220×10^6	$10^{10} - 10^{11}$	$50 - 200 \times 10^3$	10×10^3	YES
MA ONLY	50×10^3	2.5×10^8	50×10^3	10×10^3	YES
TIME SHARED SA	303×10^6	$(303 \times 10^6) \times T$*	–	300×10^3 OR 25×10^6	NO
MA + TIME SHARED SA	303×10^6	$(2.5 \times 10^8) + (303 \times 10^6) \times T$	50×10^3	310×10^3 OR 25×10^6	YES
DEDICATED SA	303×10^6	1.6×10^{12}	303×10^6	300×10^3 OR 25×10^6	YES
DEDICATED TDRS**	606×10^6	2×10^{12}	606×10^6 (SMALLER % OF ORBIT)	600×10^3 OR 50×10^6	YES (PART OF ORBIT)

* T = SA TIME PER ORBIT ALLOCATED TO SASP

**THE DATA RATES SHOWN FOR THE DEDICATED TDRS OPTION ASSUME THAT COMPATIBLE GROUND DATA FACILITIES ARE AVAILABLE TO SASP DURING THE DATA DUMP TIME

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SASP VS FREE FLYERS - TDRSS UTILIZATION

By recording data from several payloads prior to dumping to the ground via TDRSS, SASP provides some distinct advantages over free-flyers. In effect, the SASP allows the combining of several data dumps (free-flyer case) into one data dump (SASP case) thereby eliminating all but one of the TDRS slew/lock times from the TDRSS timelines. Additional timeline savings are available because SASP would have a high dump rate capability ($\geq$ 32 Mbps) which would make the dump times short compared to a free flyer with lower rate recorders. The shorter dump times make TDRSS timeline scheduling easier, reduce operational costs associated with TDRSS, and decrease the probability of data loss due to schedule conflicts.

A second advantage for SASP over free-flyers is that MA channel usage is more feasible for SASP than for free-flyers. MA channels require more user EIRP than SA channels for equivalent data rates. The need for high EIRP makes it difficult for free-flyers to use the MA capability. SASP will have sufficient EIRP, through the high gain antenna, to use MA channels at reasonably high data rates.

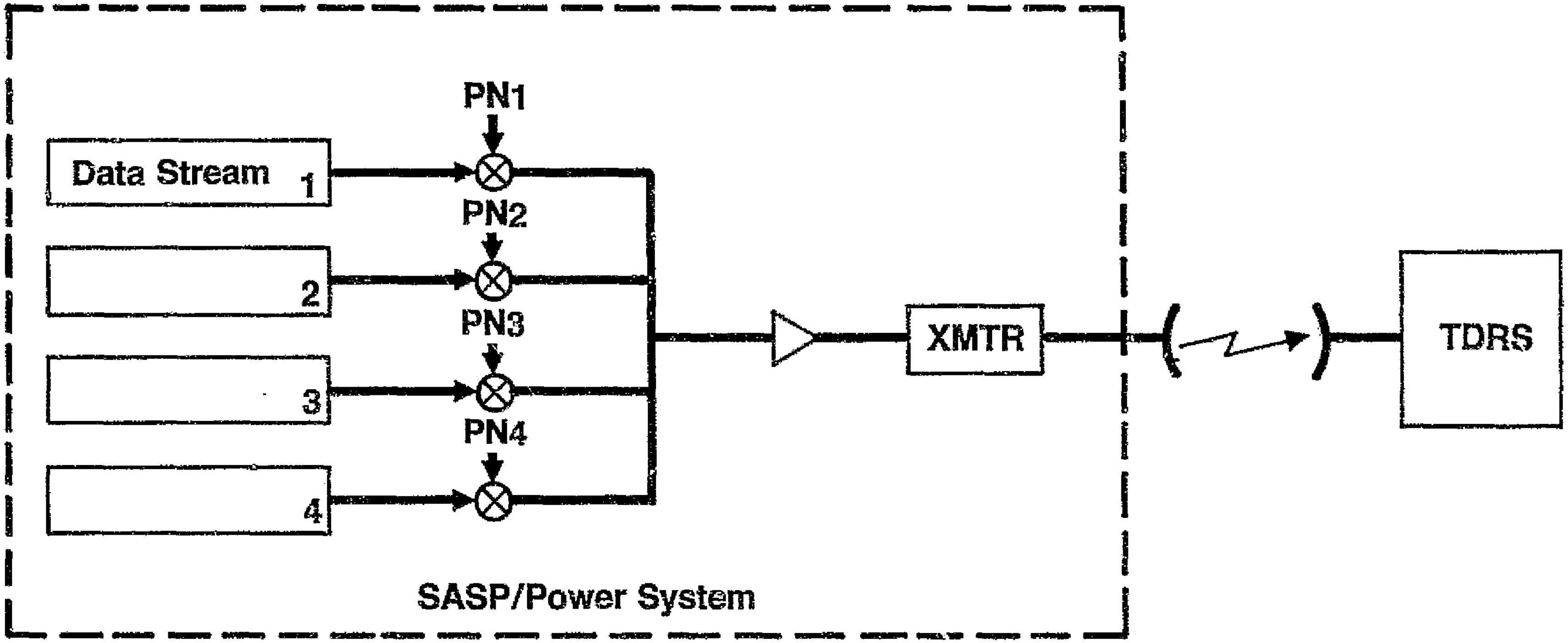
SASP VS FREE FLYERS - TDRSS UTILIZATION

- SASP Provides Better Utilization of Single Access Channels
  - SASP Can Dump Data From Several Payloads in One SA Schedule Block - Thereby Saving Antenna Slew/ Acquisition time
  - SASP, With a Spacelab Data Recorder (or Better) Can Dump Data Much Faster Than Most Free-Flyers
  - User Requirements for SA Channels will be Reduced, and Data Loss Probability will be Reduced by use of SASP With its More Effective Use of TDRSS.
- SASP Provides a Better Capability for MA Channel Use
  - Higher EIRP Needed for MA Channel Use - Not Attractive for Free-Flyers

APPROACH TO TDRSS MA USAGE > 50 KBPS

A large percent of possible SASP payloads require "continuous" or "near real-time" data communication to the POCC at rates up to 50 Kbps per payload. Simultaneous operation of more than one of these payloads on a SASP means that a "continuous" channel with capacity greater than 50 Kbps, possible up to 200 Kbps, is needed. TDRSS multiple access (MA) channels, which are intended for dedicated use of a single user, are limited to 50 Kbps. An approach to achieving the required continuous data rate is to use more than one MA channel for SASP. The TDRSS is designed to accommodate up to 20 MA users simultaneously. The 20 MA return channels (only one forward MA channel is available) operate at the same carrier frequency and are discriminated by PN spread spectrum coding and by TDRS antenna gain. Multiple MA channels from a single user (SASP) would not have different antenna gain characteristics and would be discriminated in TDRSS by PN coding only. This will tend to increase channel-to-channel interference. However, preliminary indications are that this approach is a feasible solution to the requirement. An alternative is to schedule a dedicated SA channel for SASP. The SA channel alternative would much more severly impact TDRSS loading and availability.

APPROACH TO TDRSS MA USAGE >50 KBPS



- Goal: Provide "Continuous" Data at Rates > 50 KBPS
- Each Data Stream is 50 KBPS or Less
- Each Data Stream has Different PN Code
- Technical Issues - (1) Mutual Interference
  (2) Power System EIRP
- Preliminary Indications Are That Up To 4 Data Streams of 50 KBPS Each Can Be Simultaneously Transmitted

END-TO-END DATA FLOW

A major challenge for NASA in the platform era is the end-to-end data flow scenario associated with multiple high data rate payloads. Once the data is delivered to TDRSS by a platform it must be sorted and delivered to the user. Users, including POCC's and PI's, will be geographically dispersed. Data rates and quantities will stress the data distribution and processing capabilities available. NASA is addressing this problem through the NASA End-to-End Data System (NEEDS) program. This program is developing system concepts and technologies to meet these challenges. Key elements of that program include on-board data processing and storage technology, ground data processing and storage technology, and system concept development. The SASP study has highlighted the importance of on-board data processing and high rate on-board data recorder technology.

As a follow on to the SASP study, MSFC and MDAC are further investigating the end-to-end data flow problem as it relates the space platforms. This study is utilizing the MSFC data system simulation capability to explore the sensitivity of end-to-end data system performance payload timeline requirements and data system configuration options.

END-TO-END DATA FLOW

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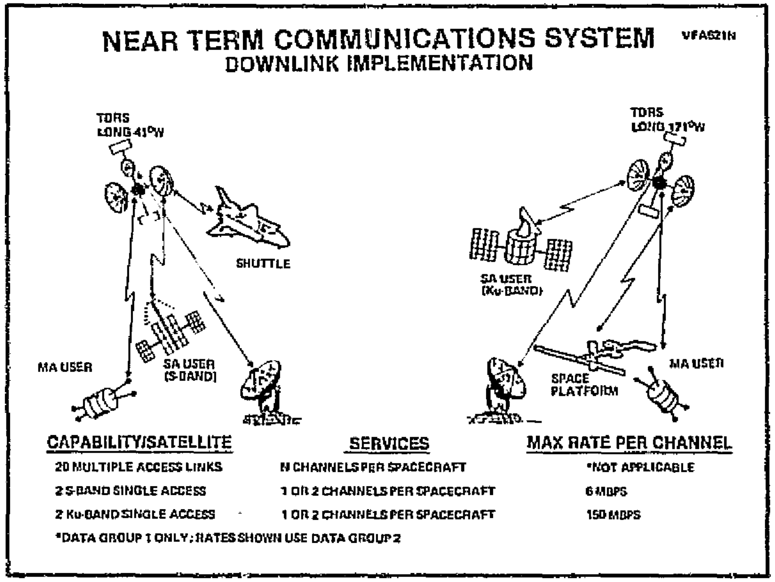

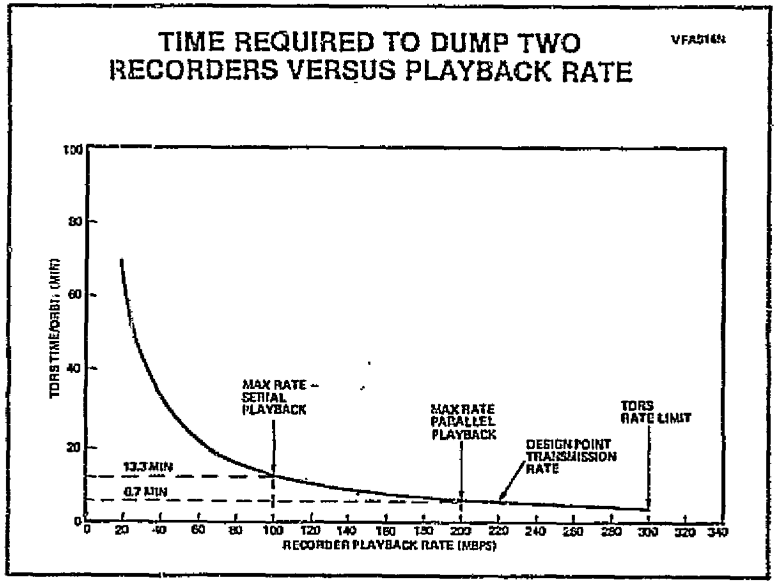

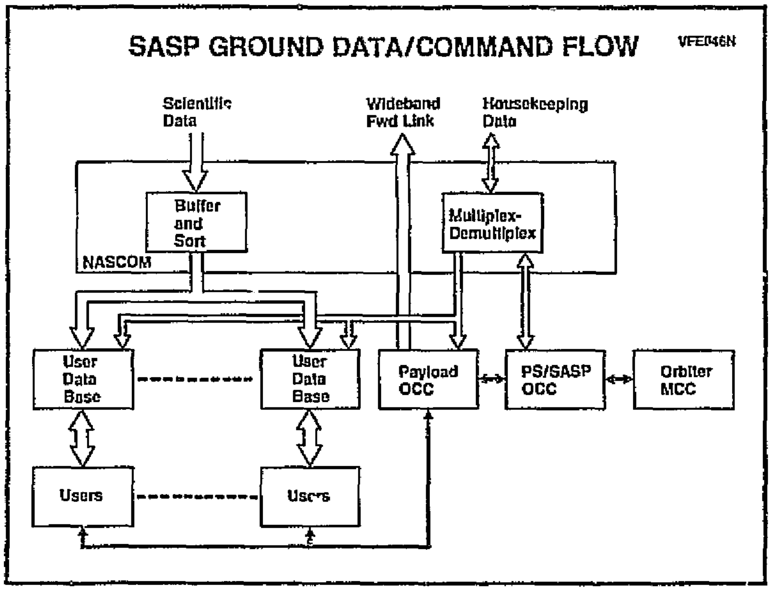

- TDRSS Constraints Can Result in Data Loss If Not Used Efficiently
- High Rate Recorders are a Key Factor in TDRSS SA Utilization Efficiency
- Ground Data/Command Flow Must be Updated to Handle High Peak Rates and Large Data Quantities
- MSFC Simulation Capability Offers Tool for Follow-on Studies

POWER DISTRIBUTION

The platform power distribution system has evolved conceptually into options ranging from distributing both dc and ac power, with provisions for utilizing the maximum peak dc power available from the 25 kW Power System (PS), to a more elemental system for distributing and controlling primary dc power only, with peak load demands exceeding nominal distribution capacity being supplied by local peaking batteries. The scope of payload power interfaces ranges from those provided for a First Order Platform where power is distributed directly from PS berthing ports, to an extended Second Order Platform which adds distribution from a central support module to payloads on crossarms and trailing arms.

As noted on this chart, the current concept provides for growth from first order to second order utilizing a "kit" approach to achieve maximum second order capability. Distribution of ac power to payloads has been deleted primarily because of the lack of a hard requirements base for cost-effective system sizing. DC distribution system capability has been increased from 5 kW continuous/8 kW peak to 6 kW continuous/9.3 kW peak at payload interfaces (exceptions are noted). User provided batteries are required to supply peaking power if experiment (payload element) demand exceeds 6.9 kW.

Development of high voltage dc distribution and utilization equipment is encouraged to provide a viable alternative to less efficient lower voltage systems, particularly for high power applications.

POWER DISTRIBUTION OVERVIEW

Basic Requirements and Provisions

- 85-90% of Payloads Require (Including Support and Growth):
  - $\leqslant$ 6 kW Avg
  - $\leqslant$ 9.3 kW Peak

  $\gg$ Concept Provides at Each Berth
- Up to 4 Payloads at 5 kW Each and 6 for 20 kW Simultaneously
- Peak Total/PS: 35 kW at 30 Vdc and 27 kW at 120 Vdc (Additive)

Feature Trades and Selected Approaches

- Radial Feeds to Payload Elements From Platform Support Module Distributors Versus Branch Circuits From Distributors at Berths
- Two 120 Vdc Bus I/F With PS (Ref) Versus Three
- AC Distributed to Users From Platform Inverter Versus Users Provide Own Inverters as Required
- Payloads Provide Own Peaking Battery/Charger for >6.9 kW Versus Numerous Options

UNIQUE DESIGN ASPECTS

The facing page lists the significant aspects of implementing the selected platform concept, its interface with the Power System and the Orbiter, as well as related technology developments.

UNIQUE DESIGN ASPECTS:
POWER DISTRIBUTION

- Cables Employed at Side-Arm Rotating Interfaces (Continuous Rotation Not Required) (Slip Rings Required Only for Trail Arm)
- Epoxy Graphite Structure Requires Hardwire Returns for Power/Signal Circuits and Platform Equipment Grounding Conductor Terminated on PS Structure
- Platform Provides Deadface Switching for De-Energized Mate/Demate of Payloads, Power System Provides Same for Platform
- Orbiter Operates on Internal Power for All Platform Docking Modes (Platform Supplies No Power to Orbiter)
- Provision to Bypass PS 120 Vdc Regulators Enhances Peak Mode Services (Batteries: Several 100 kW Unreg for Minutes)
- Expandable Truss Sections Require Use of Superflex Power Wiring
- Distribution Penalties (Losses, Wiring Design for Expandable Trusses, Weight, Multiple Parallel Cabling Requirements) at 30 Vdc Are Significant. Both Distribution and Utilization at Higher Voltage Should Be Emphasized for High Power Systems

MAJOR TRADES: POWER DISTRIBUTION

The principal factors considered in these first two trades shown on the chart lead to the selected approaches checked on the right. The chief reasons for selecting radial feeds from support module distributors to the payloads (upper right on chart) are to increase isolation between individual payload elements (experiments) and between payload elements and supporting subsystems. The recommendation to add a third (isolatable) 120 VDC interface circuit from the 25 kW Power System (lower right) will not only provide maximum isolation capability but also will enhance platform distribution system flexibility.

For peak/pulse power loads, addressed at bottom of chart, the platform distribution system will accommodate individual payload element peak power requirements up to 6.9 kW. Available payload data has indicated relatively few requirements for peak power greater than this level before taking quantum jumps to 25 kW and higher. Certain applications present high pulse power demands on the source and may require leading edge rise times faster than can be supplied by batteries alone. In addition, the using system may operate at voltages considerably higher than nominally available from the Platform Power System.

For most applications, approach A is adequate. Peak power up to 6.9 kW is supplied directly to the payload element at either 120 VDC or 30 VDC. Considerably more power could be supplied for short durations by making modifications to the PS and platform distribution systems as covered in previous briefings.

Approach B utilizes platform power capability to charge a peaking battery provided by the payload. This arrangement gives maximum flexibility to the user. It allows scheduling combinations of high peak power - short duration loads, lower peak power - longer duration loads, and/or pulse power loads at user specified voltage levels, limited only be definable platform charging power constraints between battery discharges.

Approach C can provide the features in B if the charger is user-provided or specified, but introduces new interface requiremetns and possible additional cost for experiment integration.

Approach D also can provide the features in B but at the expense of compounding interface control requirements and user integration costs relative to C. In addition, if the load demands pulsed power and the leading edges of the pulses are steeper than the battery can supply, compensating capacitors may be required in the payload. This may further complicate the interface by requiring control of the dynamic impedance presented to the payload by the charger, battery, and interconnecting power lines.

MAJOR TRADES: POWER DISTRIBUTION

VFG226N

Branch Feeds to Payload Elements	Vs	Radial Feeds to Payload Elements

Branch Feeds to Payload Elements

- Lower Cable Weight
- Highest Common Impedance
- Highest Single Point Failure Risk

Vs

Radial Feeds to Payload Elements ✓

- Increases Cable Weight
- Maximizes Isolation Between P/L's
- Higher Indicated Reliability

Two 120 Vdc PS I/F's

- Reference PS Baseline
- Lower Cost
- Restricts Distribution Flexibility to P/L's

Vs

Three 120 Vdc PS I/F's ✓

- Greater Distribution Flexibility
- Increased Switching on Platform
- Adds I/F Circuit From PS
- Maximum Isolation From Transients

A. Peak Power Direct, Platform to P/L

Vs

B. P/L Peak Battery/Charger ✓

- Maximum User Flexibility
- Minor Interfaces

Vs

C. Payload Peak Battery, Platform Charger

Vs

D. Platform Peak Battery/Charger Plus Payload Capacitors As Required

POWER ALLOCATIONS/DISTRIBUTION INTERFACES
SASP SECOND ORDER PLATFORM CONFIGURATION

This update of power allocations incorporates inputs from TRW for payload pointing (Dornier system) and subsystem support equipment requirements. Note that no power is allocated to payload subsystems for thermal control. A central thermal control system (TCS) is provided by the Platform. An allocation of 640 watts at 400 Hz is shown for TCS pumps located in the platform support module (SM).

The allocation of 4000 watts continuous power for payload elements is unchanged from the Midterm Briefing. However, peak power has been reduced from 8000 watts to 6000 watts. This reflects the specific constraint in DOD RFP F04701-79-R-0060, Experiment Requirements for Space Test Program Sortie Support System, Appendix 4 to Annex A to Attachment 1, which limits experiment peak power to 1.5 X experiment average power. Use of the 1.5 factor also is in keeping with criteria used in previous platform studies conducted by MSFC. Experiment data analyzed by MDAC has shown limited instances of higher ratios of peak to average power, but it is felt that the 1.5 X factor should be used for experiments in the 6 kW class unless a higher factor is developed from the TRW experiment data base study.

Power requirements for the platform subsystem are broken down to the component level versus the subsystem level reported at Midterm. Allocations of power to the platform subsystem, payload elements, and payload subsystems including provisions for growth and contingencies are indicated by power level (continuous/peak) and type (120 VDC, 30 VDC, 400 Hz) in the interface diagram on the right. Equipment grounds continue to be shown, but are not required throughout the Platform since some structural sections such as the standoff from the PS are now aluminum instead of graphite epoxy as previously baselined.

POWER ALLOCATIONS/DISTRIBUTION INTERFACES, SASP SECOND-ORDER PLATFORM CONFIGURATION

VFE066N

Power Allocation in Watts

Payload	Continuous	Peak
• Payload Element	4,000	6,000
• Pointing (Dornier)	617	1,645
• Subsystem		
Computer and I/O	525	525
Support Electronics	182	182
	5,324	8,352
• Growth Allocation	676	976
Totals	6,000	9,328
Platform		
• High Rate Multiplexers	400	400
• High Rate Digital Recorders	250	500
• RIU's	35	35
• Thermal Control	640	640
• Trail Arm Rot. Drive	50	200
• Other Drives/Mechanisms/ Viewing Lights/TV Cameras	Intermittent	
	1,375	1,775
• Contingency	225	275
Totals	1,600	2,050

Distribution Interfaces

Power	Type
4,600/6,900	120 vdc Payload Elements
4,600/6,900	30 vdc Payload Elements
1,400/2,428	30 vdc Pointing and S/S
	Equipment Ground

Payload (Typ)

Platform Power Distributors

Platform Subsystem

Power	Type
	Equipment Ground
910/1,210	30 vdc SM
640/640	400 Hz SM TCS Pumps
50/200	30 vdc Arms

+ Intermittents

FIRST ORDER PLATFORM POWER DISTRIBUTION BLOCK DIAGRAM

The First Order Platform provides the capability to supply individual payloads with power up to the rated capacity of the PS, less allowances for platform subsystem loads (mechanisms, drivers, etc.), and distribution losses. The 25 kW 120 VDC interfaces at the +Y and -Y ports are additions to the 25 kW Power System reference concept defined in PM-001. While not shown, use may also be made of the +Z port which can supply rated 25 kW capacity at either 120 VDC or 30 VDC.

The platform power distributors provide the required buses, power monitoring circuit protection, and switching for deadface mating/demating with either the PS or the payload.

SECOND ORDER PLATFORM POWER DISTRIBUTION BLOCK DIAGRAM

The Second Order Platform incorporates the support module with its central command/data and thermal control systems. In addition to its expanded capability to accept different and varied payloads, the Platform provides a berthing mechanism for the Orbiter. Three 30 VDC buses nominally rated at 7 kW, 7 kW, and 11 kW, respectively are provided at the Orbiter/Platform interface to support the Orbiter and its payloads in a sortie mode. This configuration can be expanded to serve additional payloads by installing "kits" which extend either the crossarms or trail arm or both. The two ports on each of the kits are rated 6 kW continuous/9.3 kW peak at both 30 VDC and 120 VDC, same as the crossarm ports on the Basic Second Order Platform. The kit which extends the trail arm is inserted between the basic trail arm structure and the support module. This kit incorporates a 360° rotary joint with a slip ring system capable of transmitting maximum available power (nominal 25 kW less platform subsystem loads and distribution losses) across the interface. This is the only configuration that requires a slip ring system. Power transfer across all other rotary joints ($\pm 90°$. $\pm 180°$) is accomplished by using flexible trailing cables.

POWER DISTRIBUTION BLOCK DIAGRAM

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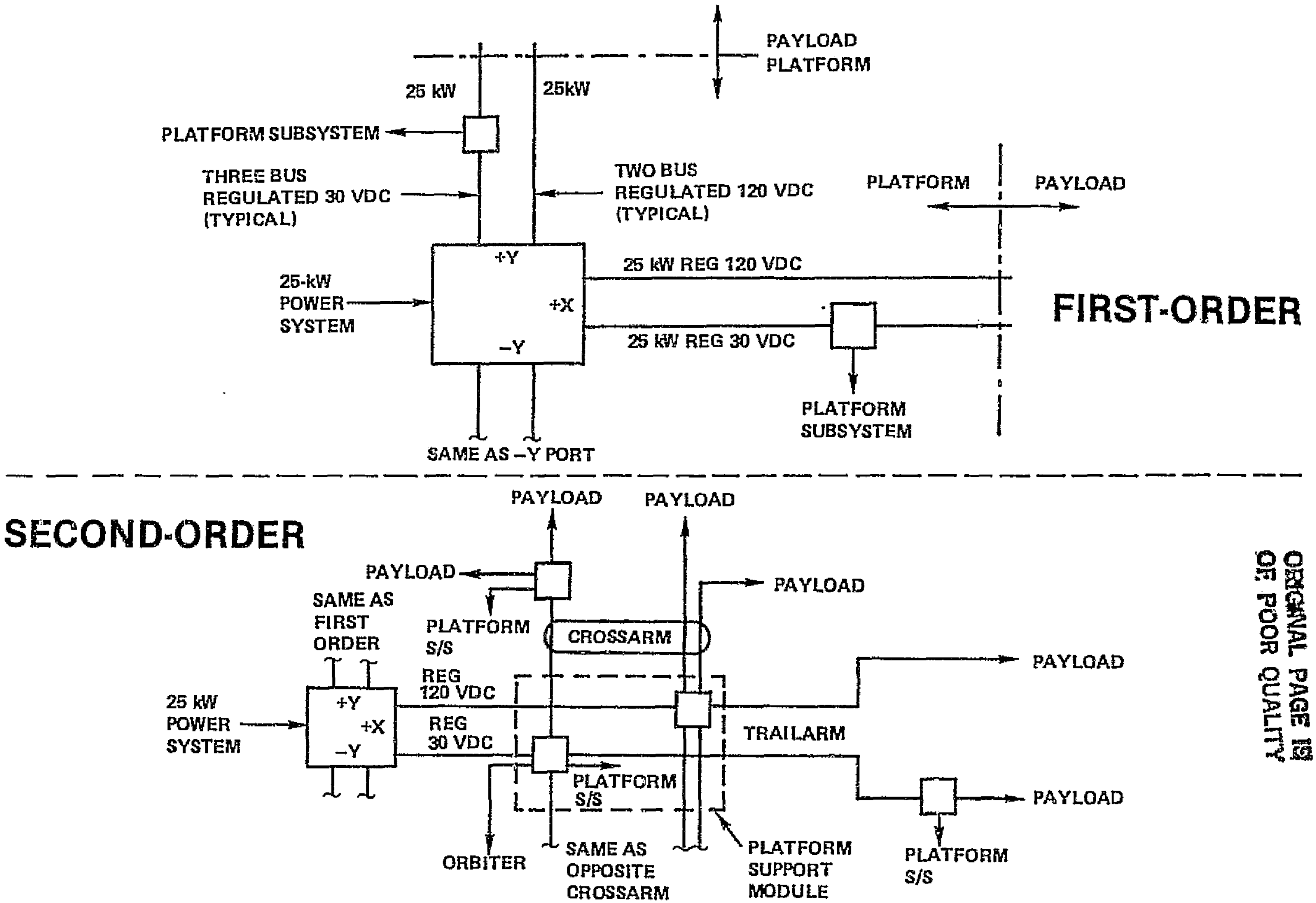

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RADIAL (ISOLATED) CIRCUITS TO CROSSARM PAYLOAD ELEMENTS

The diagram on the facing page shows the preferred approach to distributing power from the support module. For the Basic Second Order Platform, all payload elements are served over radial circuits direct from the support module distributors (slip rings and distribution for payload elements are not required in the basic second order configuration).

The advantages of this approach are that it (1) provides maximum isolation between payload elements for both the basic and extended second order platforms, (2) increases isolation between payload subsystems, (3) offers higher indicated reliability, and (4) offers lower indicated system cost, although at the expense of scar weight to readily accommodate growth to the extended second order configuration. The principal disadvantages are (1) increased cable weight, and (2) increased number of trailing cable installations to cross rotating interfaces. The total number of cables may be reduced, however, due to elimination of distributors for the payload element circuits.

RADIAL (ISOLATED) CIRCUITS TO CROSSARM PAYLOAD ELEMENTS

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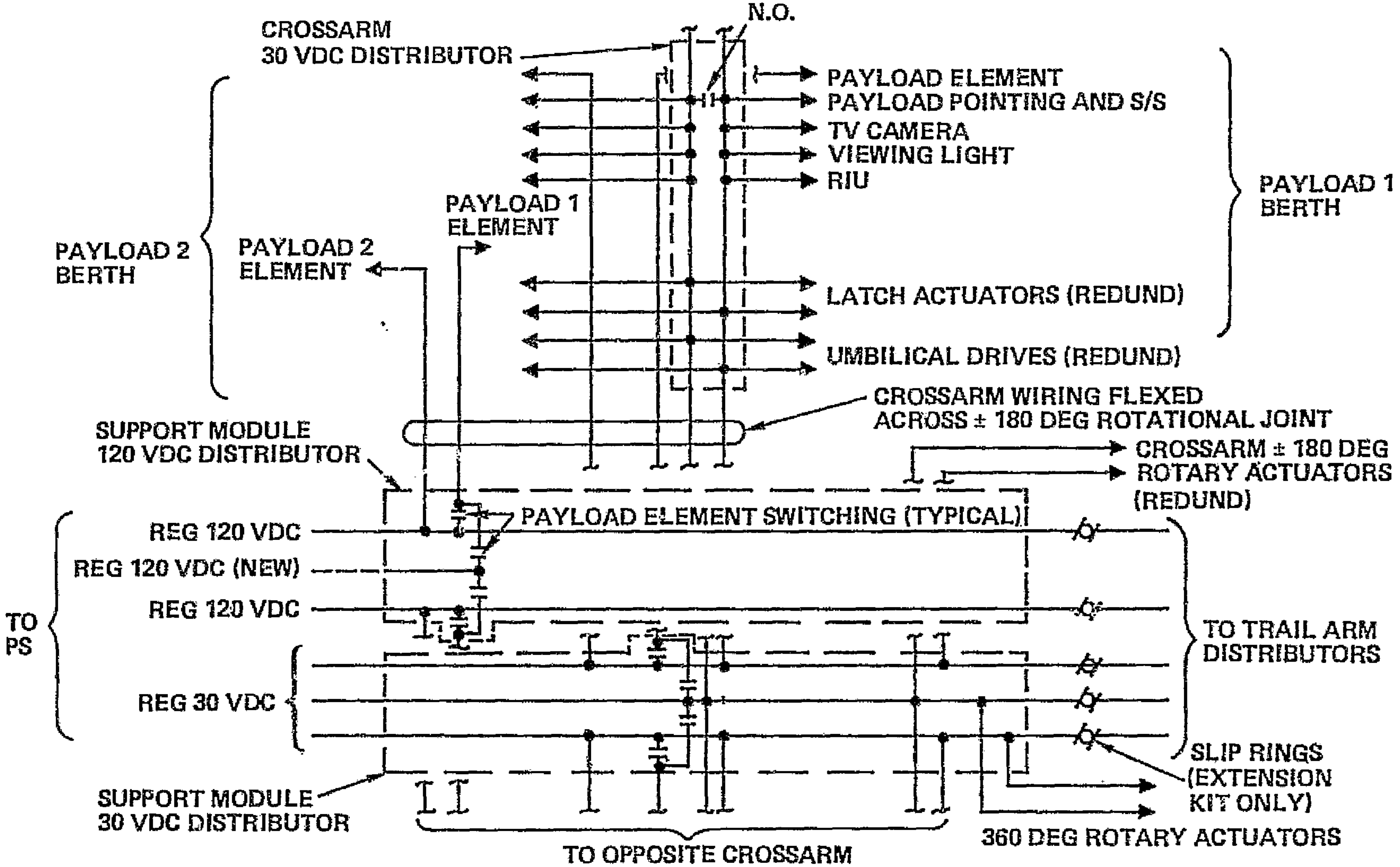

- PROTECTIVE DEVICES OMITTED FOR CLARITY
- SWITCHING SHOWN ONLY WHERE REQUIRED TO INDICATE BUSING CONCEPT
- POWER CIRCUITS TO PLATFORM SUPPORT MODULE DATA/COMMAND/THERMAL SUBSYSTEMS NOT SHOWN
- ORBITER INTERFACE NOT SHOWN

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THERMAL CONTROL, CONTAMINATION, POWER SYSTEM INTERFACES, AND MANNED ACCESS MODULE

BILL NELSON

PLATFORM THERMAL CONTROL

At the design point, cooling must be provided to each payload in an amount equal to electrical power input less any heat loss directly to space. Depending upon payload design, orientation, geometry, and effect of other nearby surfaces, heat can be lost or gained directly with the environment. Heat leak can be designed into the payload equipment for passive thermal control to account for all or part of the cooling. This option is discussed in a later chart but was not included as a study option largely because (1) PI's want to minimize need for detailed thermal engineering on their payloads, and (2) passive approach is complicated by use of alternate carriers. Additionally, a statement from the "SASP User Review Group" was that the PS/SASP must provide for 25 kW of heat rejection.

Some passive thermal control is necessary for some payloads, such as IPS mounted equipment. Therefore, additional study of passive concepts is recommended for specific payload designs. A key study trade addressed the question of where heat rejection should be performed, i.e., on the Platform, Power System, pallet, or combinations of these. Other trades optimized the Platform and payload provided active thermal control options. A centralized concept was selected in the study which uses the Power System radiators plus a platform radiator located on the platform standoff section. This approach is independent of payload carrier design and therefore, is applicable to alternate carrier designs.

PLATFORM THERMAL CONTROL

VFG338N

KEY ISSUES

- Design Requirements
- Amount of Passive Cooling
- Heat Rejection By PS, Platform or Pallet (Carrier)
- Design Optimization of Concepts

WORK ACCOMPLISHED

- Requirements Analysis
- Interface Options
- Concept Optimization
- Centralized Versus Decentralized
- Off Design Point Performance

RESULTS

- Requirements Based on Power Input
- Pallet Concept with External Serpentine Tubes
- Centralized Using PS and Platform Standoff Section
- Less Hardware and Higher Performance for Centralized
- Additional Effort Recommended for Passive Concept
- PI Input: Minimize Need for Thermal Engineering by Payload Provider
- Alternate Payload Carriers Complicate Passive Approach

THERMAL CONTROL ACCOMMODATION

- FIRST ORDER PLATFORM -

Heat rejection for the First Order Platform is by Power System radiator only, there is no platform supplemental radiator. As shown on the right side of this chart, three ports are available which can provide cooling fluid interfaces for payloads when the Orbiter is not docked. Two are available when the Orbiter is docked. Nominal fluid temperature to payloads is 60°F, return is 110°F.

The amount of cooling available to payloads depends on beta angle and the total power being supplied to the payloads. At full 25 kW power output, 10 to 16 kW are available to the payloads, 3.33 to 5.33 kW per payload. Under this full power condition, the payloads would have to provide supplemental heat rejection.

As the power to the payloads decreases, Power System parasitic is reduced, therefore, more heat rejection is available to the payloads. Of particular interest is the point where the payloads provide no supplemental heat rejection, i.e., power to payloads just equals heat rejection for payloads. Under these conditions 13.5 to 17.5 kW total cooling is available to the payloads or 4.5 to 5.83 kW per payload.

THERMAL CONTROL ACCOMMODATION FIRST-ORDER PLATFORM MODE

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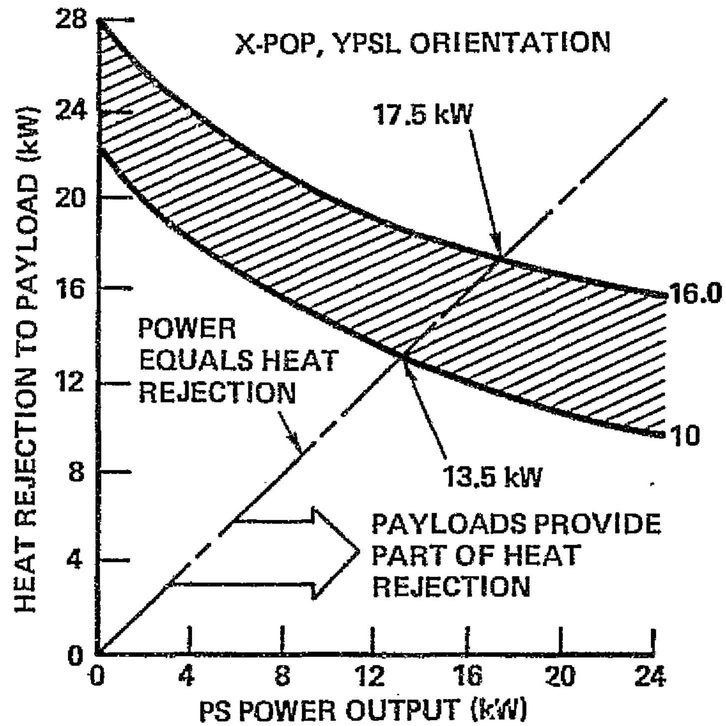
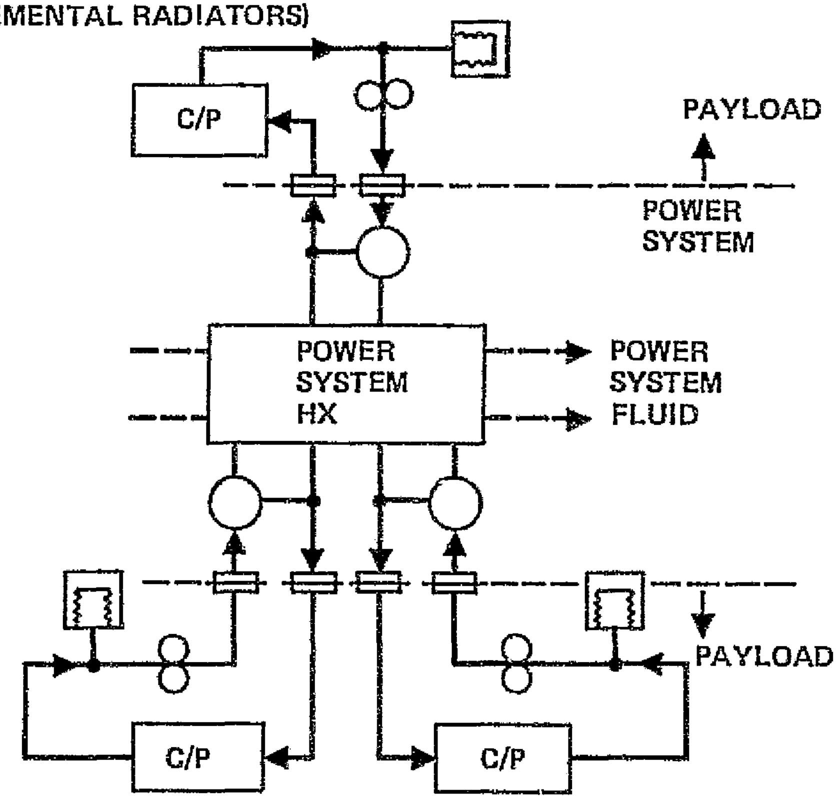
POWER SYSTEM ONLY (NO PLATFORM, THUS NO SUPPLEMENTAL RADIATORS)



SUMMARY

- 10 TO 16 kW AVAILABLE AT 25 kW POWER OUTPUT
- 13.5 TO 17.5 kW AVAILABLE FOR POWER OUTPUT EQUAL TO HEAT REJECTION
- AT POWER BELOW 25 kW, POWER SYSTEM PARASITICS ARE LESS AND HEAT REJECTION FOR PAYLOADS INCREASES



SUMMARY

- 60-110°F NOMINAL TEMPERATURE RANGE
- THREE PORTS AVAILABLE INCLUDING ORBITER PORT

PLATFORM HEAT REJECTION OPTIONS

This chart highlights the three most competitive options to accomplish heat rejection. The Power System represents a very attractive method in that it is available with the current Power System design at little penalty. The Platform need only provide a means of interfacing with the payload.

Substantial radiator surface area is available on the platform structure for heat rejection. The non-deployable portions are particularly suited because rigid radiators can be permanently installed. Use of deployable structure for mounting radiators is undesirable because they would required a complex design for installation on-orbit with EVA.

Analysis has shown that about 12.5 kW heat rejection is available on the standoff section of the Platform. Up to 33 kW is available if both the standoff section and non-deployed portions of the cross arm are used.

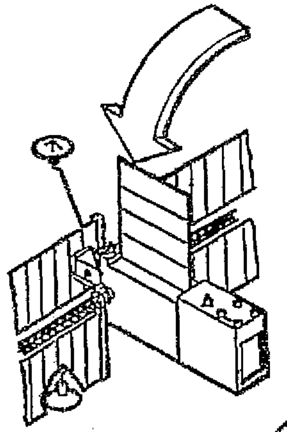
Pallet side mounted radiators can reject up to 3 kW of heat which is less than the 5 kW requirement. This deficiency can be overcome by using deployable radiators, however, this significantly complicates the design. Other disadvantages of deployable pallet radiators include possible physical and thermal interference with adjacent payloads, the Power System and platform elements. Packaging the deployable radiator will be troublesome on the larger experiment packages. Pallet radiators will require special ground handling equipment and procedures to prevent deterioration and damage to the surface coatings.

The crucial element for Platform and Power System heat rejection is the disconnect which is necessary for heat transport from the payload. A highly reliable, long-life design is necessary. A failed disconnect can cause loss of a payload port or total loop. Failure isolation, repair, or replacement by EVA is feasible followed by recharging of the loop fluid by EVA or via a special payload pallet provision.

An advantage of Platform and pallet heat rejection is that only one flight system is required wherein heat rejection on the pallets would require radiator systems for all flying systems plus additional ground units.

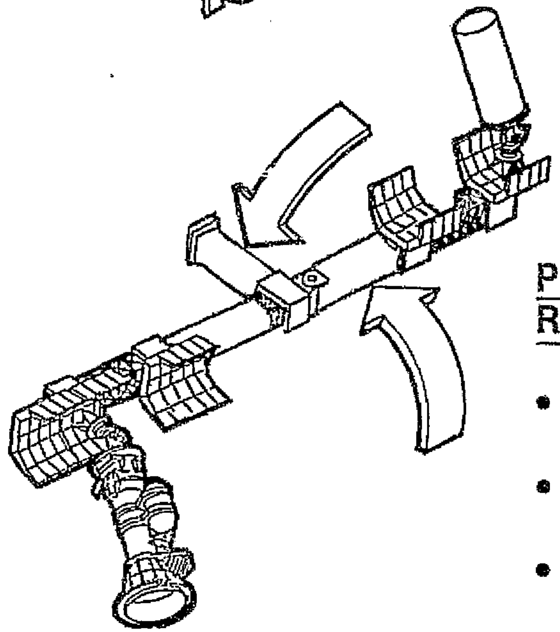
Because of adequate performance and less total complexity and cost, the use of Platform and Power System radiators is chosen.

PLATFORM HEAT REJECTION OPTIONS



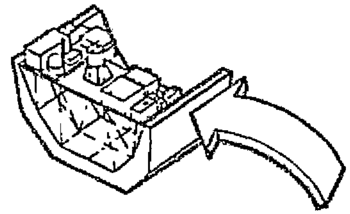
Power System Radiator*

- 10 to 16 kW Available at 25 kW Power Output
- 60-110°F Temperature
- Interface Costs Only
- Fluid Connections Required
- Increased Capability Desirable



Platform Mounted Radiators*

- 12.5 to 33 kW Cooling for Nondeployed Area
- Limited Hardware Required
- Fluid Connections Required



Pallet Radiators

- 2.6 to 3.0 kW for Fixed Concept
- Large Number Required
- Special Ground Handling Required
- Deployable Type for Large Heat Loads
- Packaging/Clearance Difficulties

*Selected Approach

PASSIVE PAYLOAD THERMAL CONTROL CONCEPT

This chart discusses the key techniques, design considerations, and program considerations for the passive thermal control concept. Insulation is used to help isolate the equipment from the environmental effects. Heaters are often needed to prevent equipment above low temperature limits. Heat pipes are used to transport heat from a high power density area to an exterior surface. Variable conductance heat pipes or shutters enables a relatively narrow range of control temperature.

The figure illustrates typical locations for different types of payload equipment. IPS mounted payloads are expected to be centrally located between pallet surfaces. Heat loads for this type equipment are small, in most cases, and passive cooling is not difficult even though the pallet surfaces can concentrate heat on the payload if the surfaces are reflective. IPS mounted equipment must be passively cooled because fluid lines cannot be run across the IPS interface for current designs because of resultant forces from pressurized lines.

Equipment mounted on the inside pallet surfaces will have reduced view factors as shown in the sketch. Mounting directly to the structure is a possible method of transferring heat to the outside structure for rejection to space.

Since passive thermal control is very geometry and orientation dependent, the thermal design will be very payload unique. Therefore, considerable design and analysis effort will be required for each payload. Detailed analysis with computer codes plus thermal vacuum testing is anticipated for design verification. These program requirements could have a schedule and cost impact.

Because the passive concept is specific payload dependent, additional effort is recommended wherein the concept is evaluated based on specific payload designs.

PASSIVE PAYLOAD THERMAL CONTROL CONCEPT

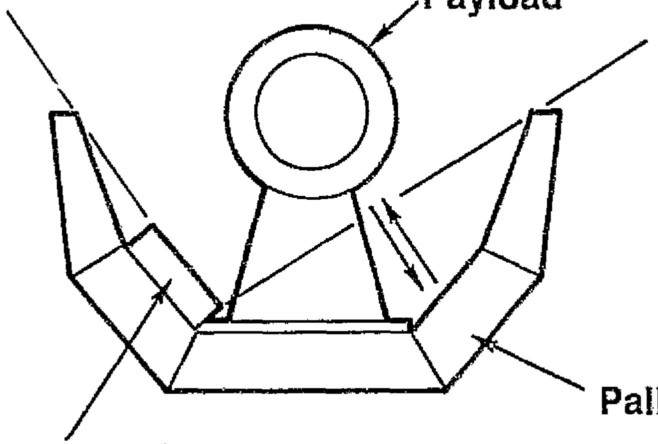
VFG357N

DESIGN CONSIDERATIONS

- Extended Surfaces
- Shorts to Structure
- Power Density
- Control Range
- Available Carrier Area/ Geometry

TECHNIQUES

- Insulation
- Heaters
- Heat Pipes
- Coating
- Shutters



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PROGRAM

- Design Payload Unique
- Detailed Analysis
- Thermal Vacuum Tests
- Some Passive Necessary
- Operational Flexibility
- Recommend Further Study with Specific Payload Designs

THERMAL CONTROL TRADES

Five key trades were performed on the SASP study which had a significant impact on the selected thermal control design. The last four trades were accomplished to select near optimum centralized concept to be traded against the pallet radiator concept which was also optimized from a design standpoint. The resultant data from these trades formed the basis for the centralized versus pallet radiator concepts.

The centralized concept was selected based on the results summarized in the next chart.

THERMAL CONTROL TRADES

TRADE	SELECTED CONCEPT	RATIONALE
Centralized versus Pallet Radiator	Centralized	• Higher Performance • Less Hardware
Loop Arrangements – Parallel or Series	Parallel	• No Interaction Between Payloads • Low Temperature Supply • Lower Pumping Requirements
Payload Interface Options	2 Loops With Direct Fluid Interface	• Less Hardware
Centralized Radiator-Dual Loop Alternates	Separate Panels	• Low Weight • Low Complexity • Low Meteoroid Vulnerability
Centralized Radiator Flow Options Comparison	Panels in Series –4 Passes Per Panel	• Highly Efficient • Low Weight • Acceptable Pressure Drop

CENTRALIZED VERSUS PALLET RADIATOR COMPARISON SUMMARY

This chart summarizes the comparison between pallet located radiators and the centralized concept. Key comparison criteria were developed for the competing concepts and these are shown in the table.

Hardware requirements differ significantly between the competing concepts. The pallet radiator concept requires more pump packages, temperature control valves, and radiator panels because each pallet is, in effect, a self-contained system. However, complexity of the pallet radiators and pump package are expected to be somewhat simpler than for the Platform. Key to the Platform System are the large number of fluid disconnects which must be used each time a payload is changed out.

Performance for the centralized system is higher, 5 kW nominal, because available fixed pallet surfaces limit heat rejection to about 2.6 to 3 kW per pallet. Deployable pallet radiators were not considered because of cost, complexity, and experiment interference.

A major drawback for the centralized radiator concept is due to the need for on-orbit Freon fluid connections. This key component must be highly reliable and have a relatively low leakage rate.

Based on the lower hardware requirements and higher performance, the centralized concept is tentatively selected for the purpose of developing programmatic data. However, due to the criticality of the fluid disconnect and because of lack of payload data on heat loss directly to space, futhermore detailed study is recommended in follow-on effort.

CENTRALIZED VERSUS PALLET RADIATOR COMPARISON SUMMARY

VFE103N

Criteria	Centralized	Pallet
Hardware Requirements		2 Packages Platform
- Pumps	2 Packages	1 Package Each Pallet
- Disconnects	2 Each Port +2	2 for PS Interface
- Temperature Control Valve	2 for Platform	1 Each Pallet
- Radiator Panels	4 for Platform	4 Each Pallet
Reliability (One Year)		
- One Payload	0.926	0.937
- All Payloads	0.830	0.819
Failure Impact		
- Loss of Platform Loop	One Arm Lost	Both Arms Lost
- Loss of Pallet Loop	One Arm Lost	One Payload Lost
Cooling Available per Payload	5 kW (Accommodates 86% of Data Base)	2.6 to 3.0 kW for Fixed Radiators (Accommodates 72% of Data Base)
Carrier Sensitivity	None	Area and Mounting
New Development	Disconnects	None
Payload Involvement	Little	Much

PLATFORM THERMAL CONTROL CENTRALIZED RADIATOR CONCEPT

The platform centralized radiator concept is shown schematically in this chart. Heat rejection is accomplished by the Power System radiator and by a separate platform radiator located in parallel. Two separate fluid loops are provided; each services half of the ports. The cross arm configuration is shown wherein each loop services a separate arm. Each loop flows 3410 lb/hr of Freon 21 which is in the design range for existing Orbiter pump units. Pressure drops in the loop are also compatible with existing pumps.

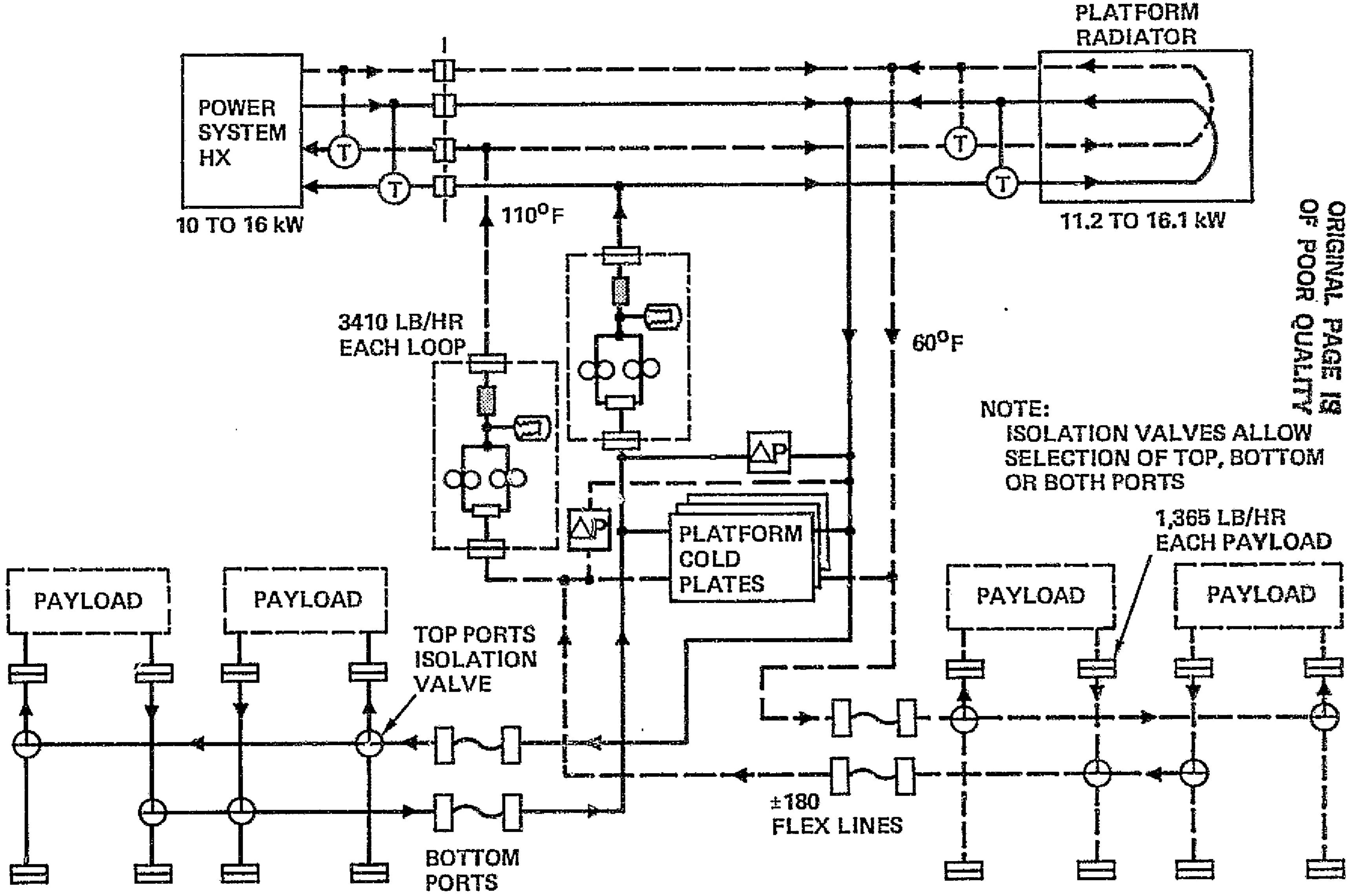
Platform cold plates are located in parallel with the payloads so that platform heat loads do not perturbate payloads and insures a 60°F fluid supply to payloads.

Fluid is directed to each arm through flex lines which allow the arms to rotate ±180° relative to the center structure. Isolation valves opposite each port location allow Freon fluid to be directed to either or both top or bottom port locations. These valves also allow isolation of either port in the event of an excessive leak in a connector or payload.

Relatively constant pressure drop is maintained between supply and return fluid lines by the ΔP valves. Payload pressure drops will be trimmed by adding orifices in their loops to provide a predetermined pressure drop at the design flow. This will ensure a minimum imbalance when the payload compliment on the Platform changes.

2ND ORDER THERMAL CONTROL SELECTED CONCEPT — SPLIT SYSTEM

VFC320N



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THERMAL CONTROL SUBSYSTEM
OBSERVATIONS AND CONCLUSIONS

At this point in the study, several specific observations and conclusions can be made, as highlighted on this chart. Results of the study indicate that heat rejection should be accomplished by a combination of Power System radiators plus platform radiators mounted on the standoff structural section. This approach is low cost, provides adequate performance, and affords operational simplicity.

The selected loop arrangement consists of two separate loops, each loop servicing half the payload ports, interfacing directly with parallel located payloads.

Peak loads can be accommodated by allowing elevated temperatures or by the use of thermal capacitors containing phase change material. The First Order Platform relies entirely on the Power System for thermal control. Up to three ports can be serviced with 60°F fluid. Cooling offered by the Power System will range from 10 to 17.5 kW.

The selected design accommodated pallets outfitted with a very simple thermal control system. Remotely operated disconnects will be added to the Spacelab design and pump units and igloo cold plates will be deleted. An accumulator might be necessary to account for fluid leakage and thermal contractions/expansions during launch, reentry, and ground phases.

The selected design which provides cooling to the pallet is predicated on the availability of a highly reliable disconnect. It is recommended that this hardware item be considered for early development to minimize program risk.

Due to the possible unavailability of Freon 21 during the platform operational time era, it is recommended that current NASA activity regarding a Freon 21 substitute be monitored carefully. In the event a substitute fluid is chosen for the Orbiter, impact of using the same fluid on Platform must be assessed.

On-orbit maintenance of platform thermal control subsystem is an efficient method of achieving long, 10-year life. However, this approach has been used in limited situations on past space programs. Additional studies and hardware development are necessary to verify on-orbit maintenance for Platform.

THERMAL CONTROL SUBSYSTEM OBSERVATIONS AND CONCLUSIONS

- Heat Rejection by Power Module Plus Platform Radiators
  - Meets Performance Requirements
  - Lowest Total Cost
  - Operational Simplicity
- Selected Loop Arrangement Has Direct Fluid Interface, Payloads in Parallel and Two Separate Loops
- Peak Cooling Loads by Capacitors or Elevated Temperatures
- First-Order Platform Offers 10 to 17.5 kW Power System Cooling at 60 to 110°F for 3 Payload Ports (No Platform Radiator Provided)
- Minimal Pallet Modification
  - Addition of Small Accumulator in Pallet Loop
  - Disconnects
  - Flow Balancing Orifice
- Critical Items
  - High Reliability Disconnect
  - Alternate Fluid to Freon 21
  - Pallet/Platform Accumulator Compatibility
  - On Orbit Maintenance Provisions
  - Degree of Passive Control

PLATFORM/POWER SYSTEM INTERFACE COMMENTS

1st Order Platform	2nd Order Platform
Power	
▪ Provide 25 kW 30 and 120 VDC at One of the y Ports ▪ Consider Adding Higher Power Capacity at One y Port for Unique Applications ▪ Provide 6 kW 30 and 120 VDC at the ± y Ports ▪ Terminate Equipment Grounding Conductor from Miniarms	▪ Consider Means to Bypass 120 VDC Regulator ▪ Consider 12.5 and 25 kW Options ▪ Provide a Third Isolatable 120 VDC Bus Interface ▪ Terminate Equipment Grounding Conductor from Platform Support Module
Thermal Control	
▪ Provide Thermal Services to ± y Ports (Pumps in PS) ▪ Performance Characteristics of PS Payload Heat Exchanger and Temp Control Logic Needed ▪ NASA Alternatives to Freon 21 ▪ NASA-MSFC Work on Disconnects	▪ Additional Heat Rejection Capability for Payloads ▪ Performance Characteristics of PS Payload Heat Exchanger and Temp Control Logic Needed ▪ Temp Control System Modifications for 40°F Service to Life Science Payloads ▪ NASA Alternatives to Freon 21 ▪ NASA-MSFC Work on Disconnects

PLATFORM/POWER SYSTEM INTERFACE COMMENTS (CONT)

1st Order Platform	2nd Order Platform
Communication Data	
■ Increase KSA Link Capability to 300 MBPS ■ Increase Capacity at SASP Port to 300 MBPS ■ Increase Continuous Channel Capacity to Approximately 200 KBPS ■ Increase Data Storage Capability	■ Increase KSA Link Capability to 300 MBPS ■ Increase Capacity at SASP Port to 300 MBPS ■ Increase Continuous Channel Capacity to Approximately 200 KBPS ■ Timing and Position Data from GPS Are TBD
Attitude Control	
■ Low-G Attitude Control Mode ■ PS Structural Distortion? ■ Pointing Reference Coordination ■ Berthing Alignment Accuracy ■ Control System Bandwidth?	■ Low-G Attitude Control Mode ■ PS Structural Distortion? ■ Pointing Reference Coordination ■ Berthing Alignment Accuracy ■ Control System Bandwidth? ■ Supplemental Control Versus Axis Skewing ■ Cooperative Control Between PS, SASP, and Pointing System Computers
Docking	
■ Provide ±y Ports ■ Mechanical/Functional Interfaces ■ Orbiter Berthing Adapter to Provide Access to All Necessary Parts	■ Mechanical/Functional Interfaces ■ Telescoping Boom or Equivalent for Orbiter Berthing and Servicing

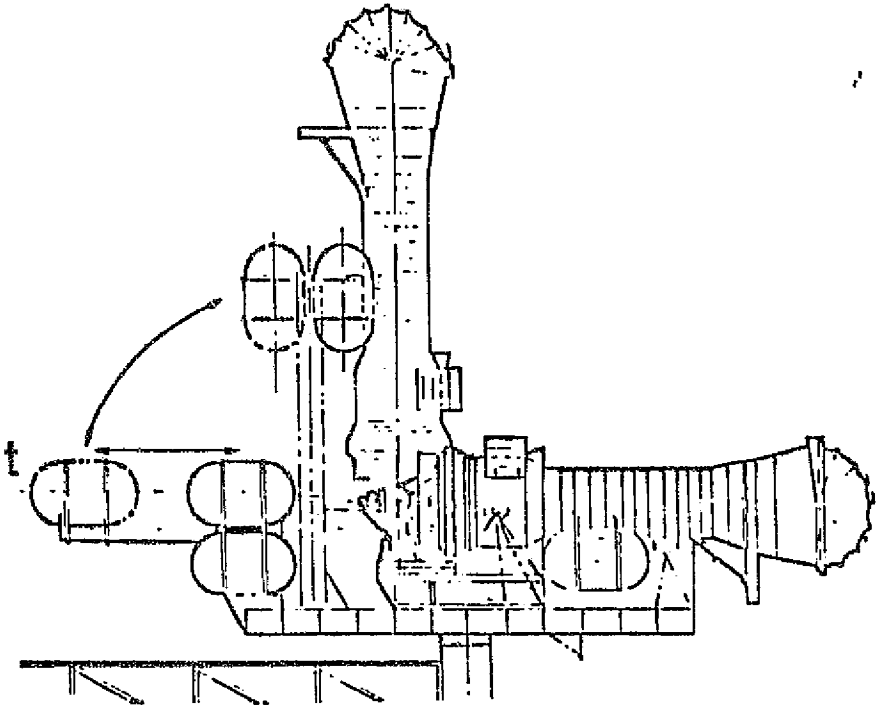
PLATFORM CRYOGENIC PROVISIONS

A review of payload requirements indicates a large number of payloads requiring cryogenics, but insufficient data are available for detailed engineering trades and studies. One payload which has the cryogenic requirements defined in detail is the SIRTF which requires 4930 liters of supercritical helium four times a year. This must be supplied to instruments mounted on an IPS which precludes transfer of cryogen from a central supply. Therefore, a centralized platform system cannot satisfy the SIRTF requirements.

A centralized concept must be replenished by tank replacement or refill. Refill approach would require some means of fluid phase control such as a passive screen device, under development, or settling forces which would require operational constraints. This approach also is somewhat inefficient because of ullage and line loss.

Specific payload cryogenic requirements are not defined in sufficient detail at this time to merit serious consideration of a platform supply system. Therefore, a payload-provided cryogenic supply concept is recommended.

PLATFORM CRYOGENIC PROVISIONS



SUBJECTS STUDIED

- Payload Requirements
- Candidate Approach Definition
- Tradeoff of Platform Supply Versus Payload Provided Concept

CONCLUSIONS

- Minimal Detailed Data Available on Payload Requirements
- Passive Cryogenic Cooling Designs Call for On-Orbit Fluid Transfer for Replenishment
- Subcritical Fluid Transfer Requires Settling Forces or Passive Screen Device
- Tank Replacement Eliminates Transfer System and Fluid Losses/Residuals
- Cryogenic Fluid Lines Cannot Be Routed Around European IPS or Sperry ASPS
- Payload Provided Cryogenic Supply Concept Recommended

CONTAMINATION PROSPECTS

Contaminating gas sources fall into three major groups: those on the Platform (including paylods); the pre-existing ambient atmosphere; and the Shuttle during its visits. Of the platform sources, the solar panels have by far the largest area and are expected to be the predominant source. They are therefore a suitable starting point for an exploratory analysis.

Continuous outgassing from the large solar panels creates a cloud of molecules surrounding the Platform. The infrared emissions from this could appear directly as noise in IR measurements. In addition, the cloud scatters ambient molecules back into critical payload hardware, such as the primary mirror in IR telescopes.

The many physical factors involved in the cloud analysis have been identified. A method of computation has been developed. A simplified model, a flat solar panel with uniform high outgassing, has been explored.

Several conclusions may be drawn from this preliminary analysis. First, the superimposed column density from the solar panel outgassing is very low. It will be on the order of 10^8 molecules/cm^2 as compared to the SIRTF detection threshold of 10^{12}. Second, this column density will be reduced even further by high ambient densities or by increased molecular cross sections. Finally, the method of computation developed here will be applicable in more detailed studies of contaminating flux.

CONTAMINATION

VFG225N

SPACELAB 1, 2, 3 EXPERIMENTS	OUTGAS ELEMENT	MOLECULES/CM^2	% OF MISSION TIME
• PLASMA PHYSICS	A	3.7×10^{14}	13
	N2	2.0×10^{15}	13
	H2	1.3×10^{15}	49
• ATMOSPHERIC PHYSICS	N2	2.8×10^{15}	28
• HI ENERGY PHYSICS	Xe	6.4×10^{11}	100
	He	1.1×10^{13}	100
	CO_2	5.4×10^{11}	100
	Xe	1.4×10^{13}	100
	CH_4		
• IR ASTRONOMY	He		
• TECHNOLOGY	He		
• FLUID AND AEROSOL DYNAMICS	N2		
	O2		
	He		
	H2SO4		
	NACL		

* NOMINAL LIMIT — OSS PAYLOADS — < 10^{12} MOL/CM^2

ORBITER EFFLUENTS

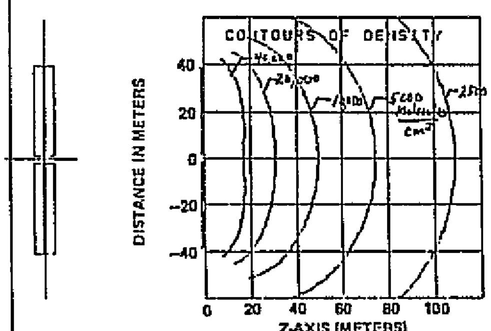
PALLETS ONLY

- OUTGASSING MIXED ELEMENTS (MOL/CM^2) 1.3×10^8 (AVG)
- EARLY DESORPTION (MOL/CM^2) 2×10^{11} (AVG)

SOLAR ARRAY LMSC DATA

- OUTGASSING
  - ADHESIVE ON SOLAR CELL COVERS — DC93-500
  - ADHESIVE BETWEEN KAPTON SHEETS — HIGH-TEMPERATURE PO
  - ADHESIVE ON FIBERGLASS CLOTH — TFE TEFLON HINGE STRIPS BONDED TO KAPTON PANELS — HIGH-TEMPERATURE POLYEST
  - SOLAR ARRAY VERTICAL AND HORIZONTAL PADDING — RT
  - LUBRICANTS ON ARRAY GIMBAL AND DEPLOYMENT CANISTE
  - S GLASS/POLYIMIDE LONGERONS AND BATTENS
- PARTICULATES
  - DRY LUBE USED ON SOLAR ARRAY TENSIONING SYSTEM (DRU
  - FIBERGLASS CLOTH — S GLASS EPOXY HINGE PINS
  - DACRON BRAIDED CORD/PANEL EYELETS
  - MATERIAL WEAR DURING EXTENTION — RETRACTION OF COIL (ALUMINUM DEPLOYMENT NUT, ALUMINUM ROLLER LUGS, RO STEEL BEARINGS IN ALUMINUM TURNTABLE, S.S. KAYDON,BEA
  - THERMAL COATINGS ON LONGERONS/BATTENS
  - MICROMETEOROID IMPACT ON SOLAR CELL COVERS, LONGER

SOLAR PANEL GEOMETRY AND CLOUD SHAPE



COMPUTATION METHOD

- 0.1 PERCENT CALCULATIONS FOR 1.0 PERCENT ACCURACY
- COORDINATE SYSTEM — PANEL CENTERED
- VARY PANEL ZONE AREA FOR REQUIRED ACCURACY

RESULTS

CONFIGURATION	AMBIENT (MOLECULES/cm^3)	Z-AXIS COLUMN DENSITY (MOLECULES/cm^2)
LOW AMBIENT —	1.6×10^7	1.601×10^8
MID AMBIENT —	7.6×10^7	1.595×10^8
HIGH AMBIENT	6.6×10^8	1.565×10^8
ARBITRARY AMBIENT	6.6×10^9	1.319×10^8
ARBITRARY CROSS SECTION X 10, 6.6×10^8/cm^3		1.319×10^8

- Sources
  - — Orbiter
  - — Pallets
  - — Payloads
  - — Power System
- Test Data Needed
- Self-Protection Is Prudent
- Minimization Is Possible Via Pre-Treatment and Favorable Scheduling of Operations

PLATFORM/MANNED SUPPORT MODULE

The Platform/Manned Support Module is configured to support pressurized Life Science and Material Processing payloads and provides a pressurized (shirtsleeve) translation between the Orbiter and berthed modules. The module is one of five concepts evaluated. The concept shown provides; (1) common berthing for the Orbiter and four payload modules, (2) berthing interface with the Power System or SASP, (3) interface connections for utility support, air exchange, and water transfer, (4) emergency vent capability, (5) Power System status panel, (6) communication/data processing interface equipment, (7) atmosphere supply and pressurization tanks, (8) EVA airlock and support equipment, (9) thermal control interface equipment, and (10) emergency pallet.

The support module shown provides excellent support for manned sortie missions and permits growth to a manned free-flying, scientific laboratory.

The baseline support module thermal control and environmental control system provides; (1) atmospheric control and pressurization gases for the docked manned payloads, airlock operation, and for the support module, (2) air temperature control and ventiliation for the support module, (3) cooling of support module equipment, (4) emergency venting capability, (5) emergency pallet for crew support, and (6) thermal control interface equipment for the supply of cooled fluid to the docked Orbiter and payload interface heat exchangers from the Power System centralized system.

The emergency pallet provides the crew up to 180 hours of support capability. The unit provides temperature control, humidity control, CO_2 control, food, water, and waste management capability. A portable life support system (PLSS) was provided for spacesuit support. Two spacesuits are located in the airlock for normal EVA.

Each docking port interface plate is provided two sets of interface Q.D.'s for thermal control. One set is provided for back-up. Nitrogen and oxygen lines are also provided at the support module interface plate at each docking port.

PLATFORM/MANNED SUPPORT MODULE

For Life Science and Materials Processing Payloads